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#213 FEBRUARY 2023

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Welcome

Ready to shoot the night sky with a 'proper camera'?

There comes a time in every stargazer's journey when they want to take better photos of the night sky than a smartphone can capture. The next step is to use a DSLR camera – with wider lenses and more control over exposures, these cameras are just as suited to night shots as they are for daytime use. But how do you use one without your pictures coming out black? Help is at hand on **page 28**, where seasoned astrophotographer Stuart Atkinson offers his tips for equipment, settings and, importantly, post-processing techniques to get your nightscapes with a DSLR looking great right from the start.

There are some fantastic targets to frame in that first DSLR astrophoto this month. Venus, the 'Evening Star', is bright all through February and will be hard to miss, low to the western horizon after sunset. A little higher in the sky is Jupiter, and a slender crescent Moon joins them both on 21 February too. Find more details about this attractive trio and lots more besides , including where bright comet C/2022 E3 ZTF will be this month, in the Sky Guide from **page 43**.

Speaking of bright visitors in our skies, this month marks the 10th anniversary of the Chelyabinsk meteor. When this 20-metre asteroid exploded over the Russian city of the same name on 15 February 2013 it shocked the world, and our very own Ezzy Pearson was sent there to report on it. On **page 36** she recalls her visit and explains how our planet's defences against large meteor strikes have been strengthened in the decade since.

Chris Bramley, Editor

PS Our next issue goes on sale on Thursday 16 February 2023.

HOW TO CONTACT US

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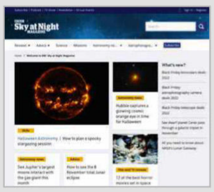
Sky at Night – lots of ways to enjoy the night sky...

Television
Find out what *The Sky at Night* team have been exploring in recent and past episodes on page 18



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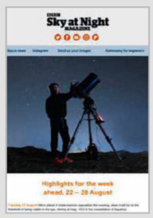

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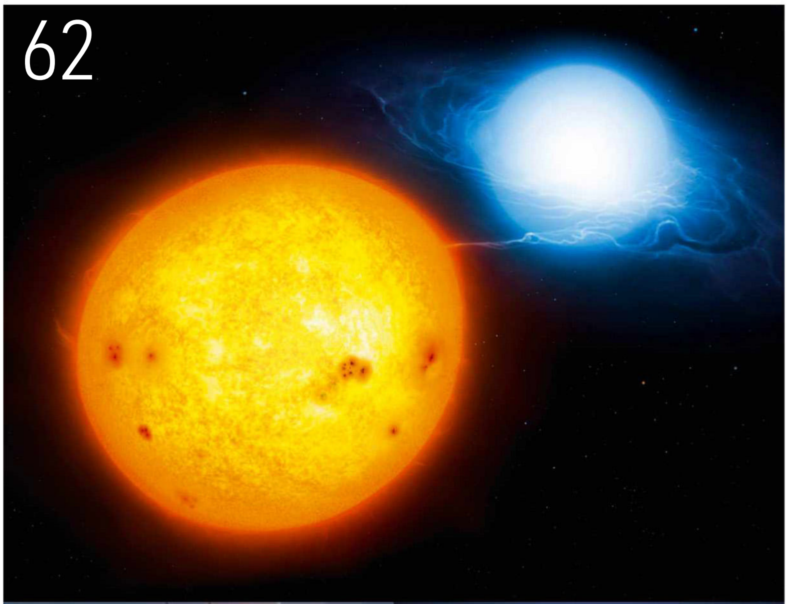
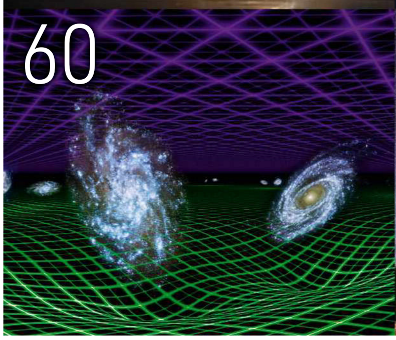
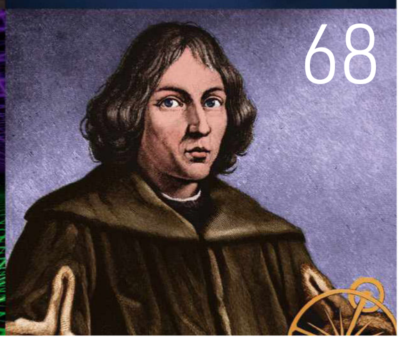
Ⓒ = on the cover

New to astronomy?

To get started, check out our guides and glossary at
www.skyatnightmagazine.com/astronomy-for-beginners







This month's contributors

Pete Lawrence

Astronomy expert

"Observing variables is a rich and rewarding activity that teaches us how to read charts, judge magnitudes and how to interpret results." **Pete shares his expert tips for observing variable stars, page 62**

Emily Winterburn

Science historian

"Although Copernicus worked out that the Sun – and not Earth – was at the centre of the Universe, he was very cautious about sharing his landmark theory." **Emily explores the life and work of the Polish astronomer, page 68**

Amy Arthur

Science writer

"The Columbia disaster was a tragedy for humanity and spaceflight, all the more so for the glimmer of hope that it could have been repaired." **Amy looks at the tragedy's causes and possible prevention, page 72**

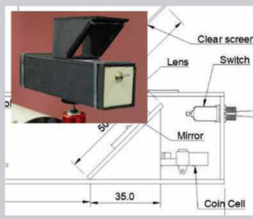
Extra content ONLINE

Visit **www.skyatnightmagazine.com/bonus-content/RRX0AL4** to access this month's selection of exclusive Bonus Content

FEBRUARY HIGHLIGHTS

Interview: Achieving interstellar travel

NASA propulsion scientist Les Johnson looks to a future in which humans venture beyond our Solar System.



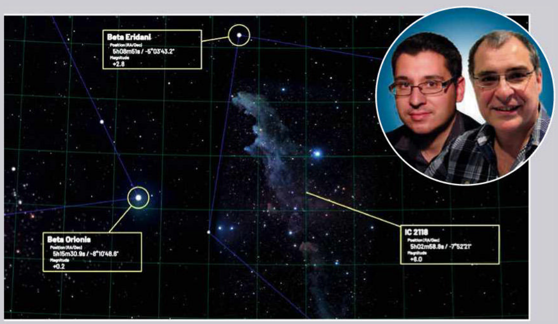
DIY Astronomy: zero-magnification finder

Access images and plans to help with this month's project: making a device that helps you locate targets with a telescope.

Access extra observing materials

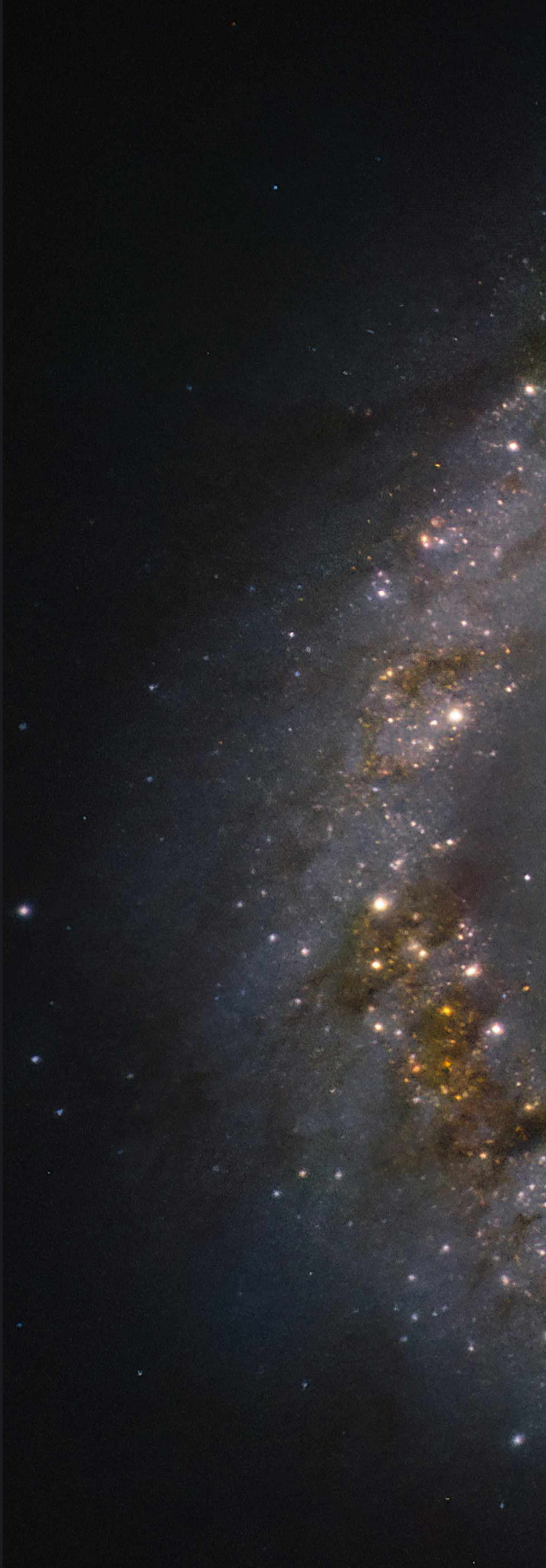
Download forms that you can use to sketch and record your planetary observations throughout the year ahead.

The Virtual Planetarium



Pete Lawrence and Paul Abel guide us through the best sights to see in the night sky this month.

STAR RING ROLE



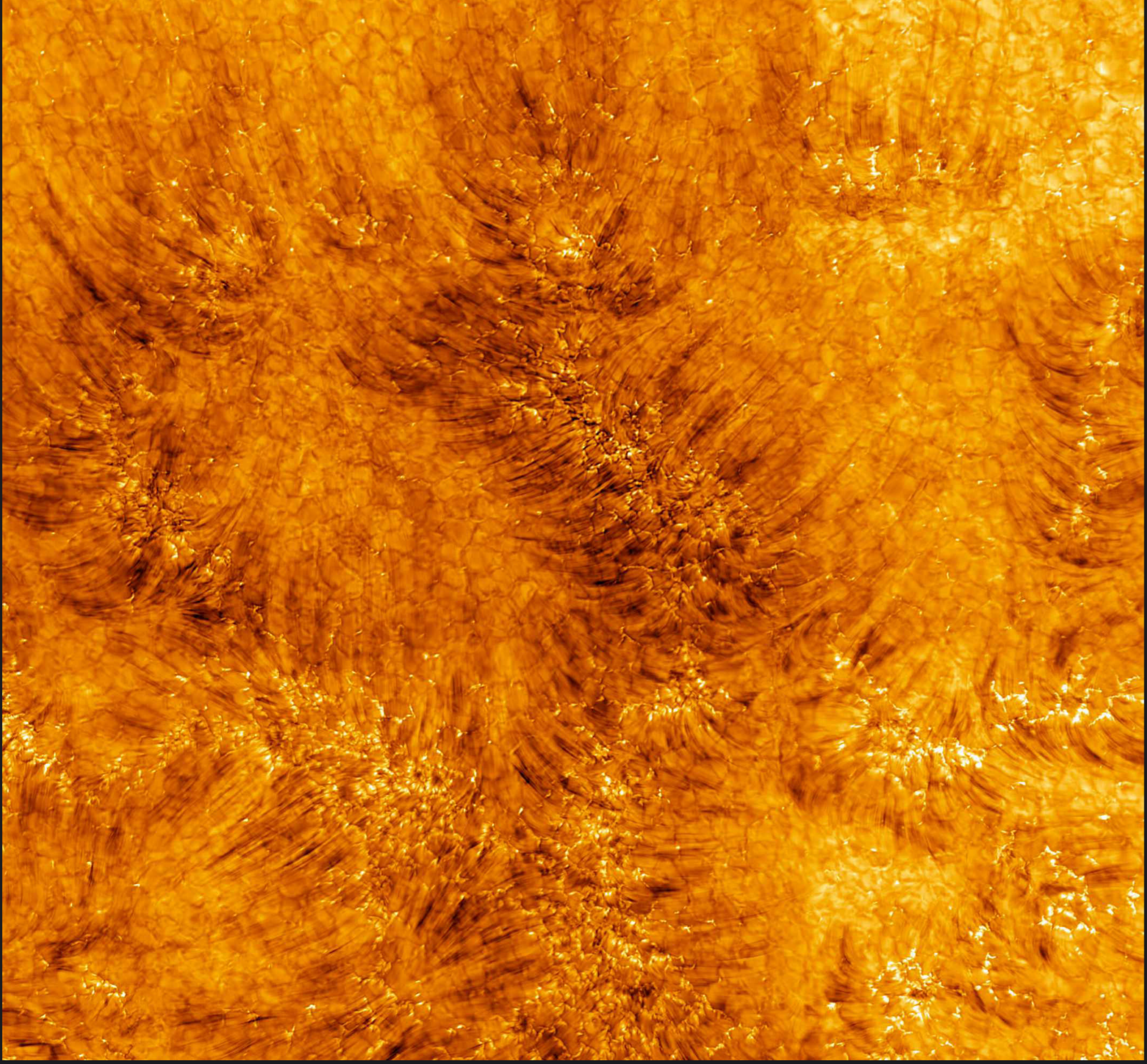
Towards the centre of a spiral galaxy, a ring of stars circles a black hole

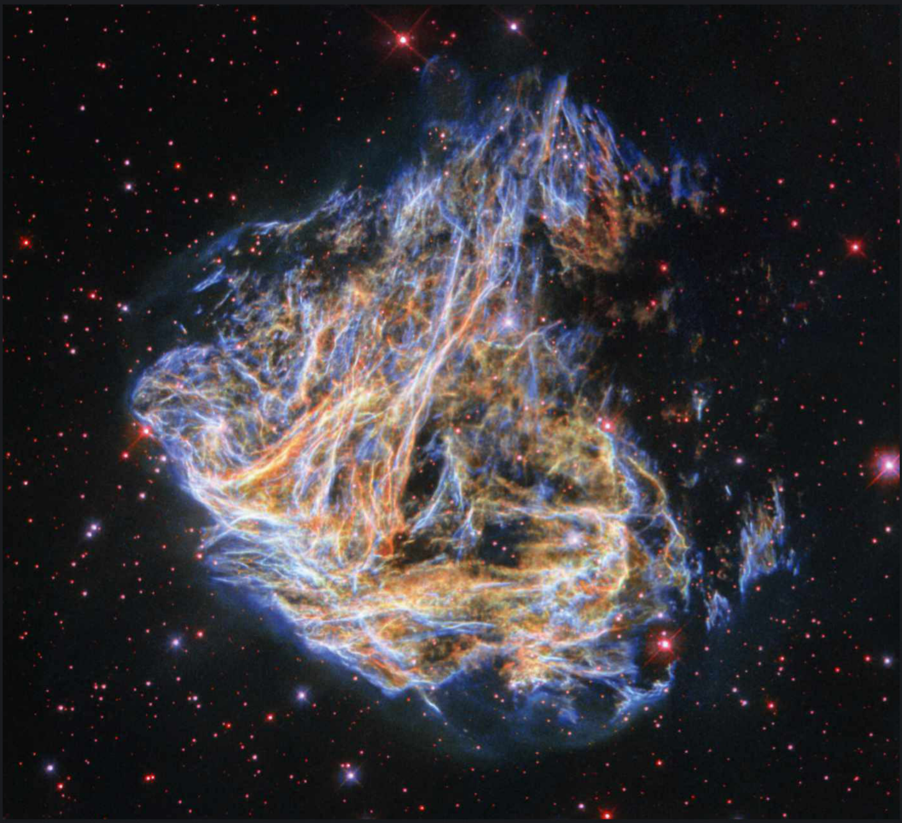
VERY LARGE TELESCOPE, 23 NOVEMBER 2022

Galaxy NGC 1097, in the southern constellation of Fornax, the Furnace, doesn't have a common nickname like some other galaxies, but this rather beautiful barred spiral takes on a different character when you zoom in on its centre, as the ERIS (Enhanced Resolution Imager and Spectrograph) infrared camera at the VLT (Very Large Telescope) in Chile did to take its inaugural image.

From a distance of 45 million lightyears, we can see an active galaxy with a quasar-like core, which is also interacting with a companion. Three supernovae have also been observed in the galaxy since 1992. The ring of bright star-forming regions that has formed around the supermassive black hole at its centre is sending gas and dust inwards. The motion of this material causes new stars to form in the ring, which is 5,000 lightyears across, but takes up a portion of the sky less than 0.03 per cent the size of the full Moon.

ESO/ERIS TEAM





△ Sun spotted

DANIEL K INOUYE SOLAR TELESCOPE, 5 SEPTEMBER 2022

The Sun's chromosphere, the atmospheric layer above its surface but below the corona, usually appears red due to hydrogen-alpha emissions, but this image uses hydrogen-beta, making it more yellow. It can't usually be seen due to the Sun's brightness. The Inouye Telescope is new – this is one of its first images, celebrating its inauguration at Haleakalā Observatory.

◁ The art in space

HUBBLE SPACE TELESCOPE, 13 DECEMBER 2022

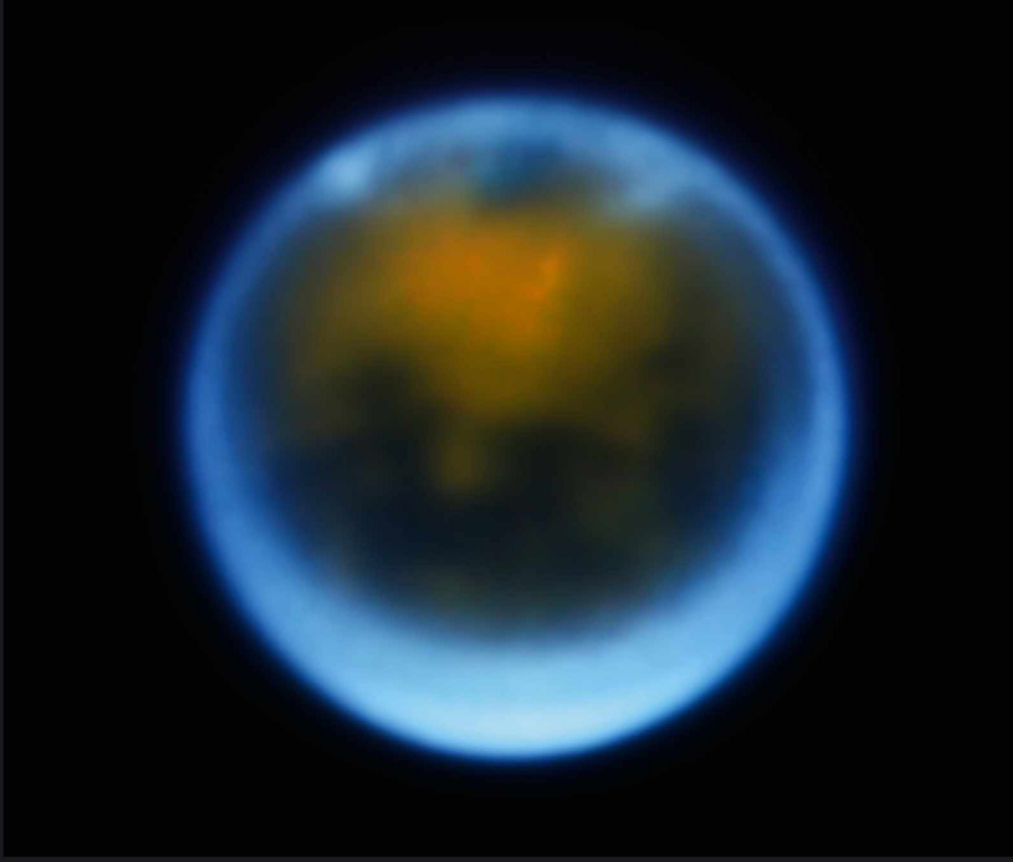
Inside the Large Magellanic Cloud lies a supernova remnant known as LMC N49. Its filaments and nebulosity paint the darkness with vivid colours, and it's thought to be 5,000 years old. It hides a soft gamma-ray repeater, which is probably a neutron star. The data is from the Wide Field and Planetary Camera 2, which was replaced in 2009, with up-to-date processing.

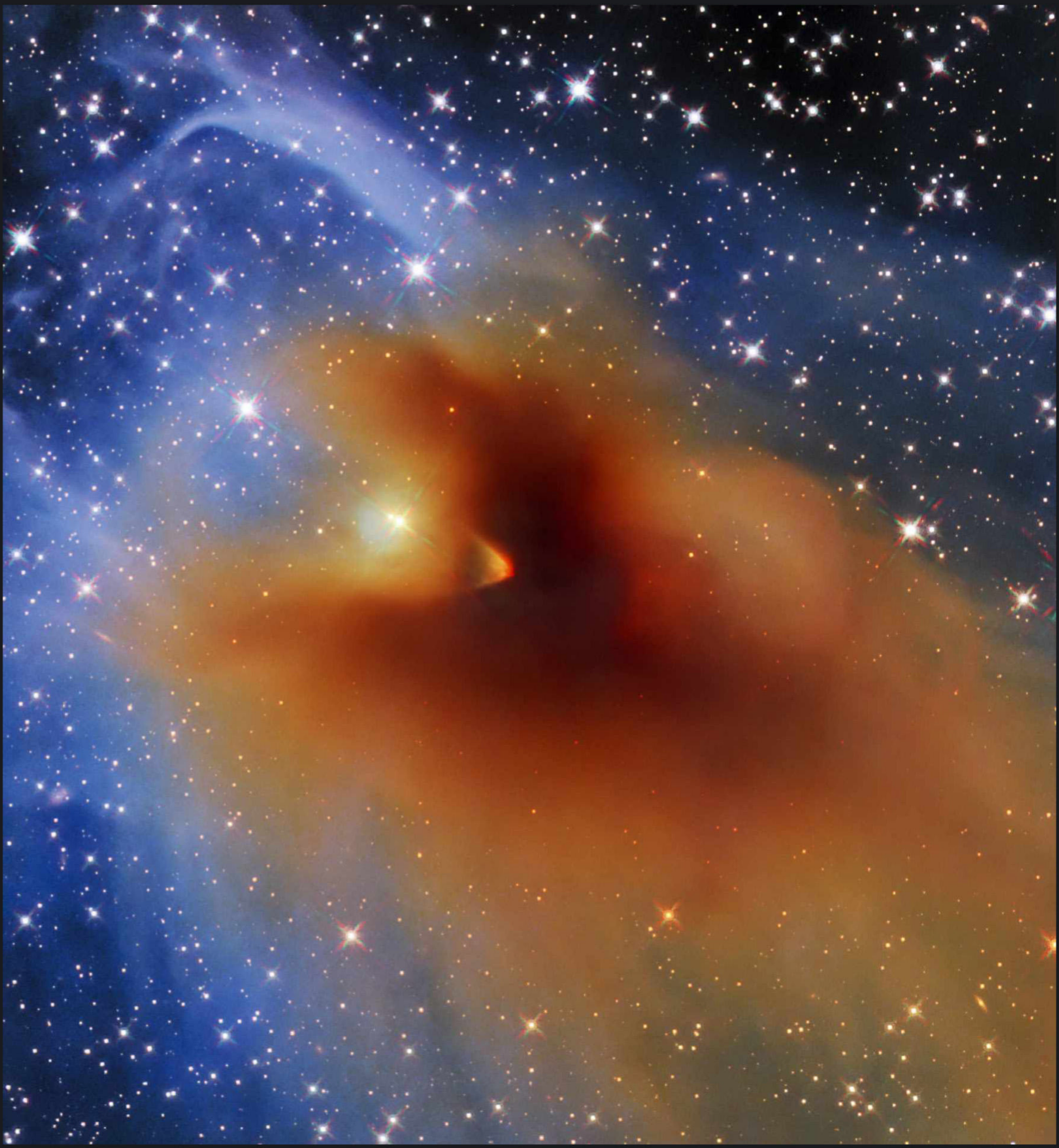
Titan quest ▷

KECK II TELESCOPE, 1 DECEMBER 2022

Saturn's largest moon, Titan, has clouds in its atmosphere and we can see them. First spotted by the James Webb Space Telescope's NIRCam, a follow-up observation was made the next day by the NIRC2 camera on the Keck II Telescope, near the summit of Mauna Kea, using adaptive optics. It saw that the clouds, the white areas at the top of the image, had changed shape. Titan is the only known moon with a thick atmosphere, and the clouds are likely made of methane.

MORE ONLINE
Explore a gallery of these and more stunning space images





◁ Something to hide

HUBBLE SPACE TELESCOPE, 18 NOVEMBER 2022

Behind this glorious orange molecular cloud lurks an object that one day will become a star. CB 130-3 is a dense core, the smallest and densest type of molecular cloud, and it sits in the constellation of Serpens Cauda, the Serpent's Tail. As the carrot-coloured cloud continues to collapse, its temperatures and densities will reach the threshold for fusion. Hubble's Wide Field Camera 3 shows the density and colour increasing towards the central area, where the protostar will ignite.

The latest astronomy and space news, written by Ezzy Pearson

BULLETIN

Light trails left by BlueWalker 3 over the Nicholas U Mayall Telescope at Kitt Peak National Observatory in Arizona

KPNO/NOIRLAB/IAU/SKAO/NSF/AURA/R. SPARKS

Concern grows over bright satellites

Astronomers have called for more protections of our night sky

A recently-launched bright satellite could pose a threat not only to visible astronomy, but also radio observations, causing the International Astronomy Union (IAU) to release a statement expressing concern over the growing number of bright satellites.

BlueWalker 3 (BW3) is a prototype for a new constellation of around 100 telecommunications satellites called BlueBird. However, shortly after it was launched on 10 September 2022, astronomers noted it was extremely bright. The IAU's Center for the Protection of the Dark and Quiet Sky from Satellite Constellation Interference (CPS) has now collated measurements of the satellite, finding it reaches around magnitude +1.0 at its brightest – similar to Antares, the 15th-brightest star in the sky.

In addition, BW3 uses the same radio frequencies as terrestrial mobile phones, but isn't bound by requirements to adhere to radio quiet zones around astronomical observatories. "Frequencies allocated to cell phones are already challenging to observe in, even in the radio quiet zones we have created for our facilities," says Philip Diamond, director general of the Square Kilometre Array Observatory – a huge new radio telescope which began construction on 5 December 2020. "New satellites such as BlueWalker 3 have the potential to worsen this situation and compromise our ability to do science, if not properly mitigated."

AST SpaceMobile, which operates BW3, has started talks with the IAU, while the Federal Communications Commission (FCC) has created a special office to address satellite constellations, ensuring they perform their important roles in global communications without affecting the scientific and cultural importance of the night sky.

"BlueWalker 3 is a big shift in the constellation satellite issue and should give us all reason to pause," says Piero Benvenuti, director of the IAU CPS.

cps.iau.org

Comment

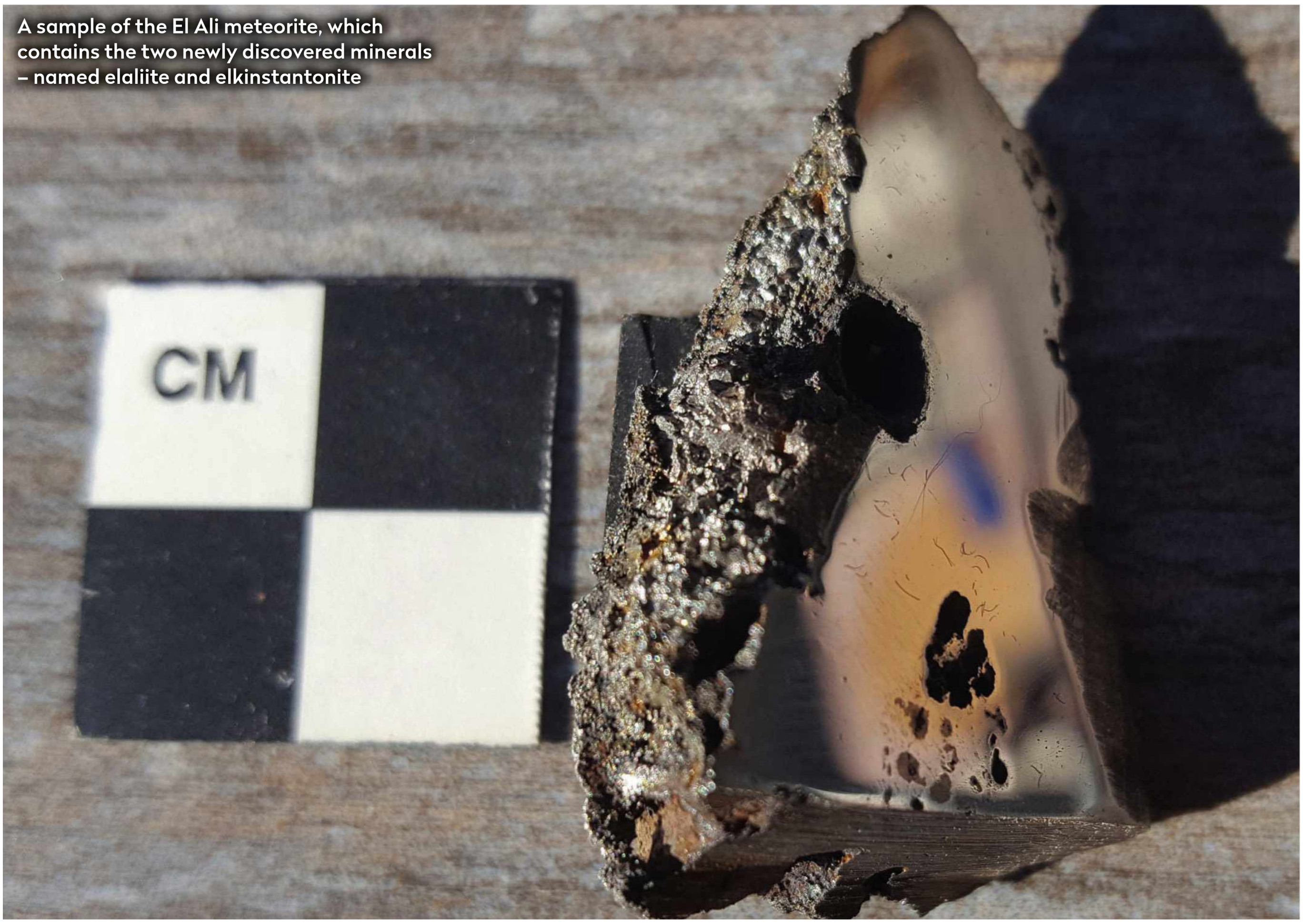
by Chris Lintott

If AST SpaceMobile has its way, there will be 243 satellites as bright as BW3. OneWeb, partly owned by the British government, plans for 648. Amazon's Project Kuiper anticipates 3,276 in orbit, while SpaceX already has more than 3,000 aloft and plans many more.

These satellites will alter our view of the night sky, interfere with our attempts to spot Earth-threatening asteroids and, according to disturbing new research, may have a significant effect on the upper atmosphere as satellites burn up.

The solution is for governments to stop, now, and work out how we want to use the precious space above our heads. Leaving it to competing companies is not going well.

Chris Lintott co-presents *The Sky at Night*



A sample of the El Ali meteorite, which contains the two newly discovered minerals – named elaliite and elkinstantonite

Previously unknown minerals identified in meteorite

The discovery could help geologists to uncover conditions deep inside growing planets

Two new minerals, never seen before in nature, have been recently discovered inside a meteorite.

The space rock was identified near the El Ali district of Somalia in 2020, but locals have known of it for much longer. They call the stone 'Nightfall' in folk songs and dances that go back seven generations. It is huge, weighing more than 15 tonnes, making it the ninth-largest meteorite ever discovered, and is predominantly made of iron and nickel.

Shortly after its discovery, a 70g slice was sent to Chris Herd at the University of Alberta for analysis. Herd soon noticed something unusual in the data, which was identified as a pair of new minerals.

"Whenever you find a new mineral, it means that the geological conditions, the chemistry of the rock, was different to what's been found before," says Herd. "That's what makes this exciting."

As iron meteorites are believed to originate in the cores of infant planets destroyed before becoming fully-fledged worlds, these minerals offer a critical window into our Solar System's growth. If you know the conditions necessary to form these minerals, then it's possible to tease out the geological history and conditions in which the asteroid formed.

Fortunately, the team had a head start in this analysis, as the minerals have previously been created synthetically in a laboratory. This also helped their rapid identification, as they could be matched to their human-made counterparts.

Now they have been found in nature, the minerals have been named elaliite, after the meteorite and elkinstantonite, after Lindy Elkins-Tanton, a prominent researcher in the field of planetary cores.

There are signs of a potential third new mineral in the rock, but it is still under analysis. Herd hopes more new minerals could be threaded throughout the meteorite, but finding them may prove difficult. The meteorite appears to have been moved to find a buyer and it's uncertain if any more samples will be available for scientific study – whether for planetary science or other research.

"Whenever there's a new material that's known, material scientists are interested too because of the potential uses in a wide range of things in society," said Herd.
www.ualberta.ca/museums


Researchers have gained evidence to support a longer 17-year solar cycle by looking back at solar magnetic fields

Are extended cycles shaping sunspots?

Twin 17-year solar cycles could be controlling the Sun's activity

The 11-year solar cycle could soon be usurped, following a new study that has given strong evidence for a rival idea.

"We call it the Extended Solar Cycle (ESC)," says Scott McIntosh from the National Centre for Atmospheric Research, who led the study. "There are two overlapping patterns of activity on the Sun, each lasting about 17 years."

McIntosh used data taken by the Wilcox Solar Observatory (WSO) since 1976 to measure the changing magnetic field of the Sun and compared that to sunspot numbers. This gave strong indications for two cycles, offset by five years from each other to create the illusion of an 11-year pattern.

"The Extended Solar Cycle may be telling us something crucial about what's happening deep inside the Sun where sunspot magnetic fields are generated," says McIntosh. "It poses significant challenges to prevalent dynamo theories of the solar cycle."

ncar.ucar.edu

Splashdown for Artemis I

The Orion capsule successfully splashed down into the Pacific Ocean on 11 December at 9:40am PST (Pacific Standard Time), completing Artemis I, the first test flight in a programme to return humans to the Moon's surface.

"The splashdown of the Orion spacecraft – which occurred 50 years to the day after the Apollo 17 Moon landing – is the crowning achievement of Artemis I. From the launch of the world's most powerful rocket to the exceptional journey around the Moon and back to Earth, this flight test is a major step forward in the Artemis Generation of lunar exploration," says NASA administrator Bill Nelson.


The safe return of the Orion capsule brings humans a step closer to returning to the Moon

The spacecraft used aerobraking to slow from 40,000km/h to just 32km/h, during which time the heatshield withstood temperatures up to 2,760°C. It then deployed its 11 parachutes in sequence to cushion the final fall back to Earth. The capsule has now been recovered for inspection.

Artemis I's flight was longer and took the capsule further than any previous human-rated spacecraft has achieved before. Its success means the first crewed test should hopefully take place by 2024, with the first landing mission as soon as 2025 or 2026.

www.nasa.gov

NEWS IN BRIEF

Hidden stars shape nebula

JWST's new infrared observations of the Southern Ring Nebula reveal two, perhaps even three, stars hiding in the dust. The images were used to reconstruct how these stars shaped the nebula as they interacted with the original star while it was throwing off around 2.5 solar masses of gas to form the nebula.

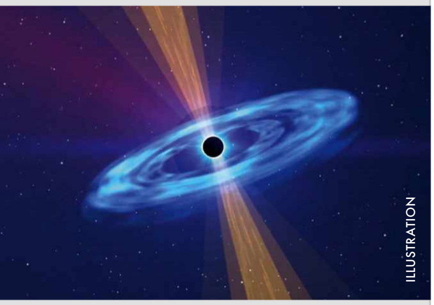
First water worlds

The first ever pair of water worlds may have been discovered in orbit around the red dwarf star Kepler-138. They are about three times the volume of Earth, but only twice the mass. The lower density indicates that a higher proportion of their mass is water rather than rock, compared to Earth – enough to flood our planet.

Survey lacks wow factor

New research into the Wow! signal's origin – the unexplained 72-second radio blast detected in 1977 – has found no sign of its cause. Previous work had identified a potential origin star system using the Gaia catalogue, but observations with the Green Bank and Allen Telescopes found no significant radio emissions.

NEWS IN BRIEF



Black hole, bright flash

A bright flash of light with the power of over 1,000 trillion suns spotted in early 2022, AT 2022cmc, was created by a jet of material moving at 99.99 per cent the speed of light, astronomers have concluded after extensive study. The jet emanated from a black hole that had just begun devouring an unlucky star.

The end is InSight

After more than four years listening for marsquakes, NASA has officially retired the InSight Mars lander, as its solar panels are now so dusty they cannot generate enough power. The lander's last communication reached Earth on 15 December, though NASA continues to listen in case the lander phones home one last time.

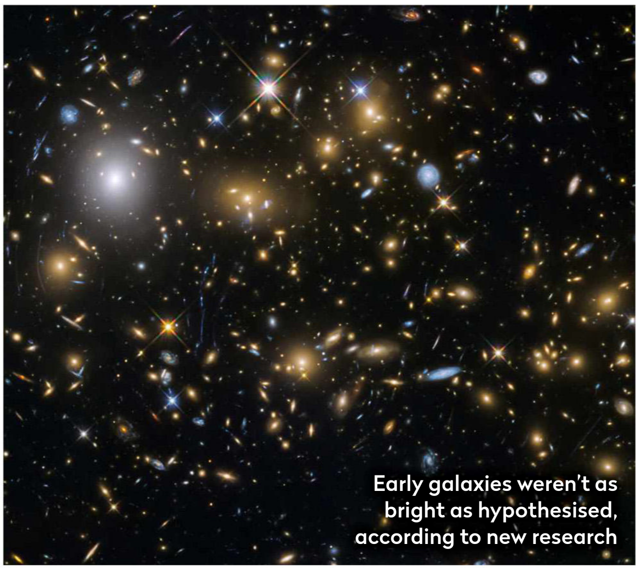
Ghostly glow

Our Solar System is surrounded by a ghostly glow, according to astronomers who have just finished measuring the background in 200,000 archival Hubble images. The glow is tiny – the equivalent of 10 fireflies spread across the night sky – but could indicate a shell of dust beyond Pluto reflecting sunlight back to Earth.

BULLETIN

Early galaxies lack cold hydrogen glow

A missing radio signal narrows down theories about infant galaxies


Early galaxies weren't as bright as hypothesised, according to new research

Sometimes what you can't see is just as important as what you can. When astronomers looked at the first generation of galaxies, which began to shine just 200 million years after the Big Bang, using the SARAS3 radio telescope in India, they noticed an important signal created by cold hydrogen atoms, the 21cm line, was absent.

"Our analysis places limits on some of the key properties of the first sources of light, including the masses of the earliest galaxies and the efficiency with which these galaxies can form stars," says Anastasia Fialkov from the University of Cambridge.

The results mean several theories about early galaxies can be ruled out – including that they were more than a thousand times brighter than current galaxies at radio wavelengths and were poor heaters of hydrogen – as well as putting upper limits on their masses. This will give key insights into the era when the Universe transitioned from being devoid of light to being filled with stars and galaxies.

www.cam.ac.uk

Japan heads to the Moon

Hakuto-R, a commercial lunar lander from Japanese company iSpace, launched on 11 December and entered lunar orbit three days later. The lander is expected to attempt a soft touch down in Atlas Crater in the northeastern region of the Moon in April 2023.

The lander has been in development for 12 years, having originally begun as a competitor for the Google Lunar X Prize. This first mission is predominantly a flight test, but it does carry several payloads including the Rashid lunar rover from the United Arab Emirates. A second mission is already planned for 2024.

However, Hakuto-R may not be the first commercial lander on the Moon, as US companies Astrobotic and Intuitive Landers are due to follow in early 2023. But successfully touching down on the lunar surface is difficult, as the 2019 crash-landing and loss of the Beresheet lander operated by Israeli organisation SpaceIL demonstrated.

"From the design point of view, we've done everything we can do," says Takeshi Hakadama, founder and chief executive of iSpace. "We have high confidence on the landing."

ispace-inc.com


Earth ringed by the second stage of Hakuto-R's launch vehicle

Our experts examine the hottest new research

CUTTING EDGE

ILLUSTRATION

Solar heating has puffed up WASP-39b to be larger than Jupiter

JWST reveals active exoplanet atmospheres

The telescope has found evidence of atmospheric reactions above an exoplanet

The James Webb Space Telescope (JWST) has been fully calibrated and operational for over six months now. The incredible images it has returned, rich with eye-popping detail, tend to make the news, but the JWST has also made a number of pivotal contributions to our understanding of the cosmos.

As part of the first round of science observation programmes, JWST has been observing transiting exoplanets. This programme was proposed and led by three principal investigators: Natalie Batalha at the NASA Ames Research Center, Jacob Bean at the University of Chicago, and Kevin Stevenson at the Space Telescope Science Institute. But the particular research paper I'm reporting on here involved some 80-odd co-authors – it represents a phenomenal collaborative effort of planetary scientists.

JWST was used to observe WASP-39b, an exoplanet orbiting a star around 700 lightyears away. It has roughly the mass of Saturn, is 30% larger than Jupiter, and orbits its Sun-like star eight times closer than Mercury is to our Sun. The team collected data across a broad range of the near-infrared spectrum while the planet was transiting in front of its star, and by analysing the absorption features were able to explore the make-up of the planet's atmosphere.

The team detected atmospheric constituents, including sodium, potassium, carbon dioxide and water vapour, which have all previously been found. But they also detected sulphur dioxide, a first for an exoplanet atmosphere. Sulphur dioxide is released by volcanism on terrestrial worlds – such as Earth, Venus and Jupiter's moon Io – but in gas giants like WASP-39b it must come from a different source.

In our local gas giants, sulphur deep in the atmosphere exists as hydrogen sulphide gas, but as this is churned up to higher altitudes the energetic photons of ultraviolet rays from the Sun break apart the hydrogen sulphide and drive further chemical reactions to produce sulphur dioxide. Such UV-driven reactions are known as photochemistry, and in Earth's atmosphere, for example, produce the ozone layer by driving reactions of oxygen molecules. This data on WASP-39b is the first concrete indication of photochemistry being crucial in the atmospheric composition of exoplanets too.

"The team detected sodium, potassium, carbon dioxide and water vapour. But also sulphur dioxide, a first for an exoplanet"

The presence of sulphur dioxide at the signal level discovered by the team also has other implications. A fundamental measure of the composition of gas giant planets is their 'metallicity' – that is, how rich they are in elements heavier than helium. These results indicate WASP-39b must have a metallicity around 10 times that of the Sun, so similar measurements of other exoplanet atmospheres can be used as a powerful tracer for heavy elements in general.

As well as marking an important first for exoplanet research – the detection of photochemical products such as sulphur dioxide – these results demonstrate just how capable this new observatory is for characterising exoplanets compared to previous space telescopes such as Hubble and Spitzer. And this bodes well for JWST's ability to probe the atmospheres of smaller, rocky planets, such as those in the TRAPPIST-1 system.

Prof Lewis Dartnell is an astrobiologist at the University of Westminster

Lewis Dartnell was reading... *Direct Evidence of Photochemistry in an Exoplanet Atmosphere* by Shang-Min Tsai et al.
Read it online at: arxiv.org/abs/2211.10490

Expansion leads to increased tension

JWST observations seem to confirm cosmology's biggest conundrum

Prof Chris Lintott is an astrophysicist and co-presenter on *The Sky at Night*

Cosmologists like an argument, and one of the biggest surprises of the last decade has been the slow emergence of a disagreement between various methods of measuring the Hubble Constant, the speed of the Universe's expansion. Two camps exist. There are those who study the cosmic microwave background, light emitted just 400,000 years after the Big Bang, and extrapolate forward to work out the Constant. They get consistently higher values than their rivals, who measure expansion directly by observing the present-day Universe. As each set of measurements has grown more accurate, this difference – euphemistically known as the 'Hubble tension' – has only increased.

JWST should help, especially with those local measurements which rely on studying Type Ia supernovae. These brilliant explosions shine with roughly the same peak luminosity wherever they occur. Knowing how bright they really are, we can work out their distance in the same way that you would judge the distance of a car by observing the brightness of its headlights when crossing the road at night. (This excellent analogy was shared with me by my colleague Becky Smethurst, and it works well – in fact, just as we could do a better job by knowing the make and model of each car, we can improve our Type Ia measurements by adjusting them according to how different types brighten and fade.)

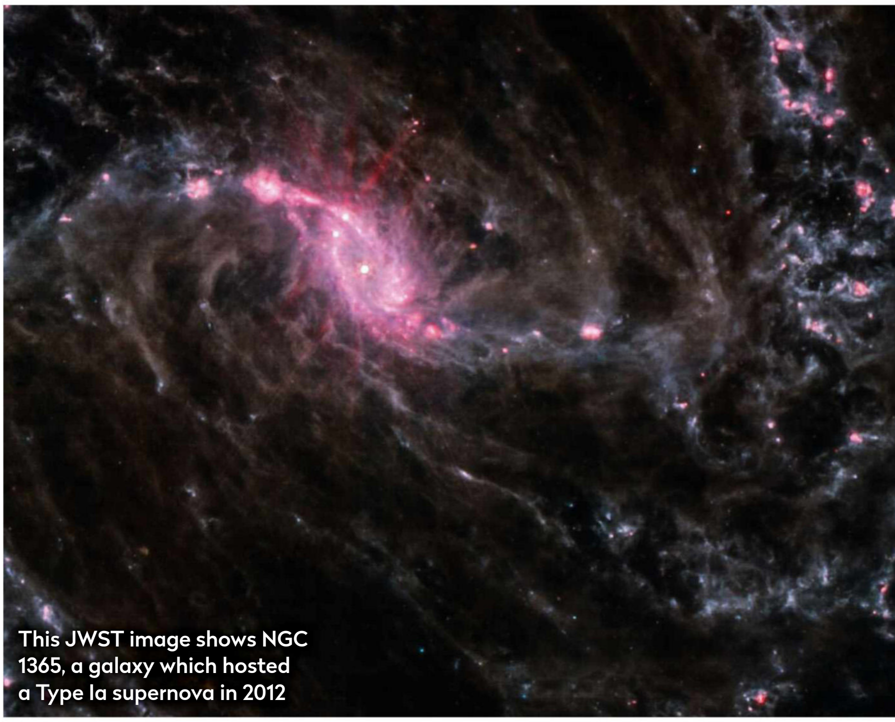
The supernova distance scale needs to be calibrated, though. Since Henrietta Leavitt in the early 20th century, astronomers have done this by spotting Cepheids, bright variable stars the speed of whose pulses reveals their luminosity and hence their distance. The Hubble Space Telescope is called Hubble because one of its original purposes was to observe more of these stars, and thus pin down the Hubble Constant once and for all.

"The Hubble Space Telescope is called Hubble because one of its original purposes was to pin down the Hubble Constant once and for all"

And yet there is still tension. One possibility is that Hubble may be systematically wrong in its measurements of Cepheids, with contamination from any red giants lurking in the background a particular worry. This sort of problem is worse in the infrared, a wavelength range often used because it is relatively unaffected by dust. While observations for the main JWST Cepheid programme have only just started, a short paper has given us a preview.

One of the nearby galaxies which has hosted a Type Ia supernova, NGC 1365, has already been snapped by JWST, as part of an effort to study its star formation, and this month's paper uses the data obtained for this purpose to check in on NGC 1365's Cepheids. The news is good for lovers of tension; these new results agree with the HST measurements, so there's no evidence of any systematic error that might bring the measurements together.

It is, though, just one galaxy. If these results are borne out by studies of many more, it'll be a boost for those cosmologists who hope that explaining the observed difference will lead us to new theories, and perhaps a new understanding of the cosmos. New results should turn up later this year; watch this space!

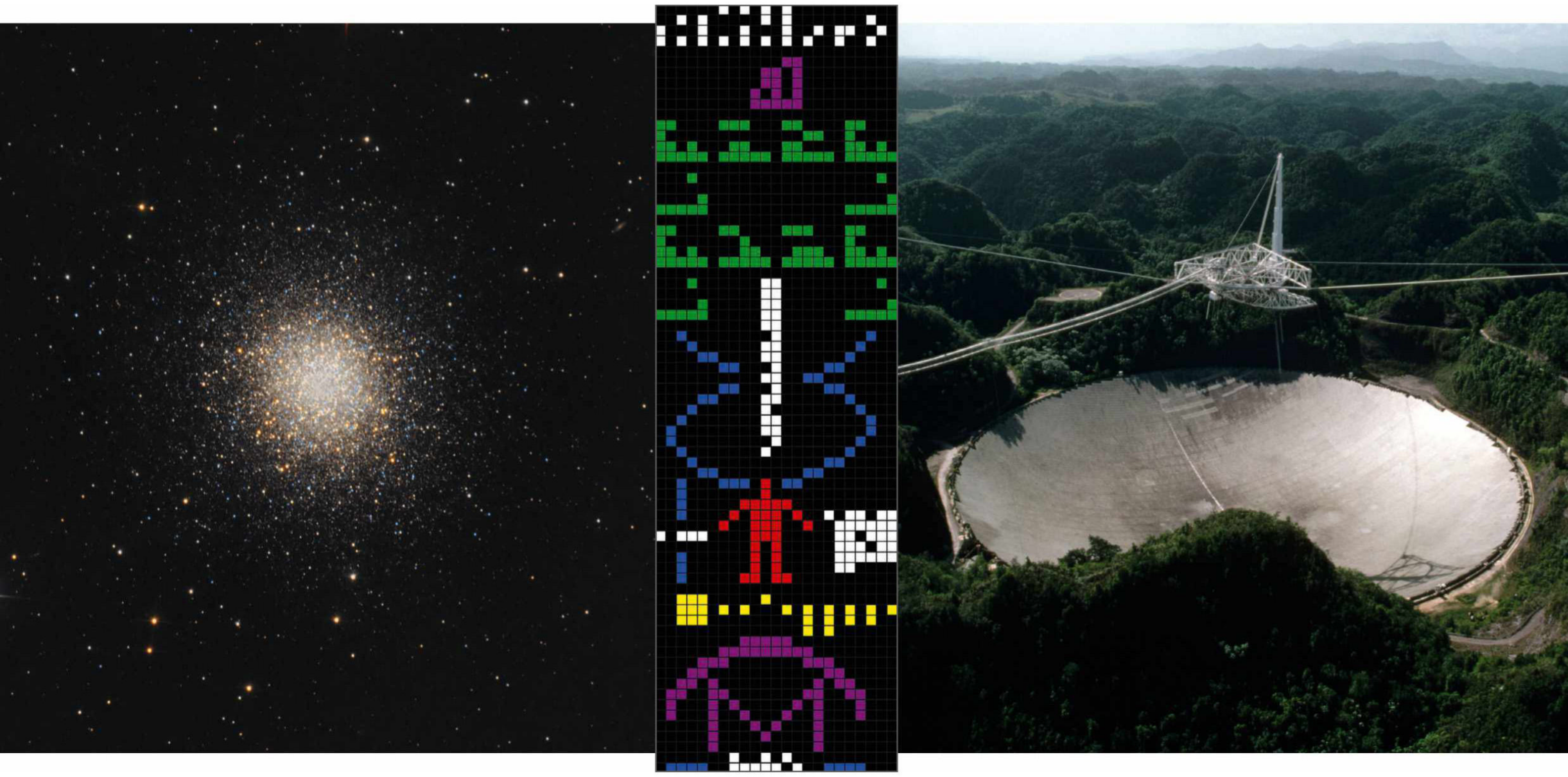


This JWST image shows NGC 1365, a galaxy which hosted a Type Ia supernova in 2012

Chris Lintott was reading... *A First Look at Cepheids in a SN Ia Host with JWST* by Wenlong Yuan et al. **Read it online at: arxiv.org/abs/2209.09101**

The Sky at Night TV show, past, present and future

INSIDE THE SKY AT NIGHT



▲ In 1974 Frank Drake sent the Arecibo message (centre) to globular cluster M13 (left) using the giant Arecibo Radio Telescope (right)

In *The Sky at Night*'s last episode of 2022, **Douglas Vakoch** looked into how humanity could reach out and contact other worlds

Where there is life, there is language. If you were to listen to Earth from the skies, you might hear one of 7,000 languages, and you would be forgiven for thinking only humans had evolved language. But you would be wrong.

Chimpanzees gesture instructions and emotions, whales sing to each other, and prairie dogs have vocal warnings so complex that experts believe they can describe the size, shape and colour of the threat to their clan. Life's capacity for language astounds me, and it gives me hope. Hope that life orbiting around distant stars may also have the capacity for language and communication.

So the question is not, "Do intelligent aliens exist?" but, "Could we communicate with them?".

In 1974, my friend the late Frank Drake sent a message to a distant cluster of stars from the largest radio telescope in the world, known today as the Arecibo message – the first radio message to aliens. At the time, what Frank sent was the result of a phenomenal effort to create a succinct interstellar postcard and then communicate it in the best way he could think of – through the universal language of maths and science. He used binary code across two different radio frequencies to communicate how we count, the structure of the DNA molecule, what humans look like, and much more.

I was a teenager back then and was inspired by Frank's ingenuity. When I grew up, I eventually joined Frank's team at SETI – the Search for Extraterrestrial Intelligence. Over the years I started to think of ways we could create and transmit a much wider range of new messages that could stand a better chance of being understood by intelligent lifeforms. And so, in 2015 I created METI International to do just that.

Art to the stars

METI stands for Messaging Extraterrestrial Intelligence, and its messages are treasure troves of science, art, and human nature, with many different ways to unlock their secrets. As we send the periodic table of elements, we talk about the chemical building blocks of the Universe – something scientists on another planet will also understand. We use maths to describe beautiful shapes that are built into nature,

M-GUCCI/ISTOCK/GETTY IMAGES, STEPHANIE MAZE/ISTOCK/GETTY IMAGES, CHRISTOPHE LEHENAFF/ISTOCK/GETTY IMAGES, BBC X 2

Douglas Vakoch is president of METI and editor-in-chief of Springer's Space and Society book series

like the spiral of the nautilus shell. And we create interstellar morality plays that start telling aliens what it's like to be human. We've designed our messages so that any alien species that is capable of receiving radio signals could decipher and understand them.

There is one more critical difference between METI's messages and Frank's: the stars we target. In 1974, Frank sent his message to a distant cluster of stars in Hercules, known as M13. This globular cluster is so far away that if SETI were to receive a response to the message, it would take 50,000 years to arrive. Who even knows if we'll still be here to accept it? We can do better than that and so, in contrast, METI sends its messages to stars much closer to home. If our messages are received, deciphered and replied to, we could receive a response in as little as a decade (if we are lucky).

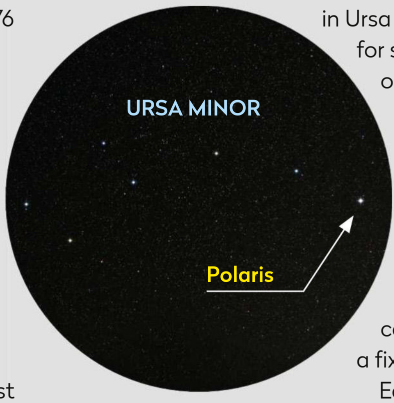
If extraterrestrials do get our messages, will they understand them? And what will they say back? Will they use the language of binary numbers? Will they show us what they look like? Will they tell us what they find beautiful? Will they say hello? To me, this is the real mystery. What message will they transmit back from their distant star? With METI, and a bit of patience, we now have a way to find out.

Looking back: The Sky at Night

18 February 1976

On the 18 February 1976 episode of *The Sky at Night*, Patrick Moore looked towards a star famed not for its brightness or scientific importance, but its position – Polaris, the North Star.

Located over the north celestial pole, Polaris is one of the first stars most people learn in the night sky, and from his home in Selsey, West Sussex, Patrick taught viewers how to locate the star. It is a common misconception that Polaris is one of the brightest stars in the night sky, but in truth it ranks around 50th (it's a variable star, meaning its exact ranking is hard to pin down). It is a mag. +2.0 star, meaning it's visible to the naked eye in all but the most light-polluted places, and is in the tail of Ursa Minor. The Plough asterism in Ursa Major points the way for stargazers, as the stars on the end of the 'blade' line up almost perfectly with Polaris.



▲ Polaris is found at the far end of Ursa Minor's tail

Patrick related the star's historic importance during the episode. As it is near the north celestial pole, it remains a fixed point in the sky as Earth rotates beneath it, an effect navigators have used to find north for centuries. However, while it appears to remain fixed over our lifetimes, the star is actually drifting due to precession, where the axis of Earth shifts over 26,000 years, causing the pole star to change. Thuban was used to align the pyramids 4,500 years ago, while in 1,000 years' time Gamma Cephei will take over, followed by Cepheus, Deneb and Vega before coming back to Thuban.

CBeebies Stargazing

There is no episode of *The Sky at Night* in February, but there is a wealth of astronomy and stargazing content on the BBC iPlayer that's suitable for children and young astronomers. The *CBeebies Stargazing Grand Tour* sees Maggie Aderin-Pocock and Chris Jarvis embark on a journey across the Solar System, inspired by the Voyager missions of the 1970s and 1980s. In each episode the team jump onboard their Space Sailor and explore a different planet, revealing the spectacular science behind the worlds of our cosmic neighbourhood.
www.bbc.co.uk/iplayer/episode/m000rjgl

▲ Join Chris and Maggie on a journey to the planets of our Solar System

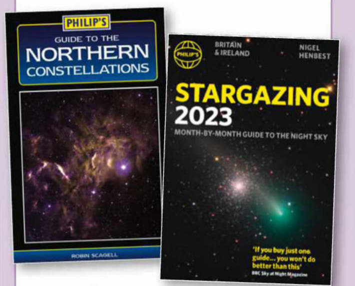
Emails – Letters – Tweets – Facebook – Instagram – Kit questions

INTERACTIVE

Email us at **inbox@skyatnightmagazine.com**

MESSAGE OF THE MONTH

This month's top prize: two Philip's titles



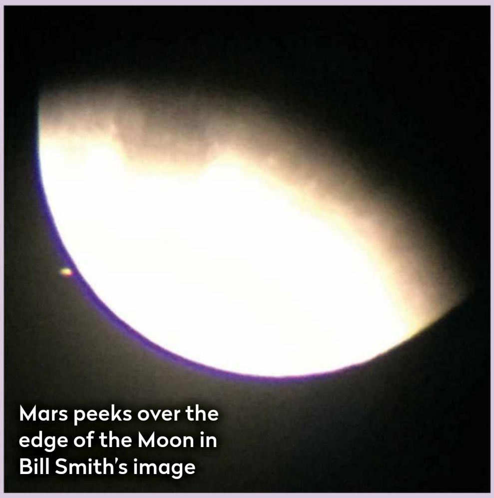
The 'Message of the Month' writer will receive a bundle of two top titles courtesy of astronomy publisher Philip's: Nigel Henbest's *Stargazing 2023* and Robin Scagell's *Guide to the Northern Constellations*

Winner's details will be passed on to Octopus Publishing to fulfil the prize

Red Planet on a mobile

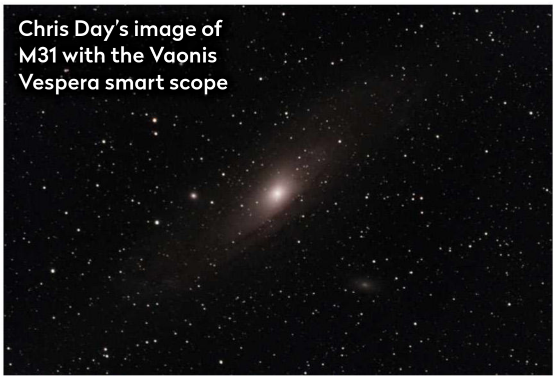
Ok, it's not taken by the James Webb Space Telescope and there's a bit of an overexposed Moon, but this is my first ever picture of Mars! Having been inspired by Pete Lawrence's article ('Capture', December 2022), on the morning of 8 December I dug out my vintage Meade ETX 70 refractor and took this picture of the lunar occultation of the Red Planet through the eyepiece, using a fairly basic mobile phone.
Bill Smith, Ayr

That's a fantastic memory of the recent Mars occultation, Bill, well done. Stay with us for more imaging advice from Pete in the coming year! – ***Ed.***


Mars peeks over the edge of the Moon in Bill Smith's image

Tweet

Epiphany Appleseed
@FunkyAppleTree • 8 December
LONDON: When the Moon & Mars kissed… #Mars #occultation #FullMoon @StormHour @ThePhotoHour

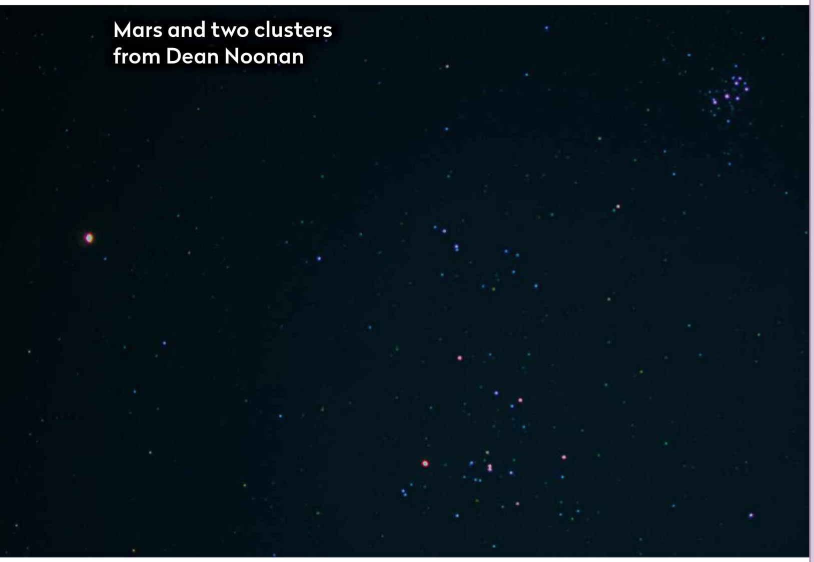

Chris Day's image of M31 with the Vaonis Vespera smart scope

Vespera success

As an original backer of the Vaonis Vespera smart telescope project on Kickstarter I have been in possession of one since summer 2022, and I was very interested to read your review ('First Light', January 2023 issue). As you say, it is very easy to set up, and I can confirm that the Singularity app is straightforward to use. I have managed to use the Vespera a few times, but I have been restricted by cloud and weather conditions. When Vaonis recently released the Mosaic mode update I couldn't wait to try it out. My first cloudless night came on 7 December, but it wasn't ideal due to a full Moon. Despite this, I had a go and I have attached the final, unedited image of M31, the Andromeda Galaxy, from that observation to give you an idea of what is possible. It was completed at 9:23pm with the City Light Suppression filter attached. One thing to note with the Vespera is that when there is a 2°C change in temperature the unit will stop because it needs to be refocused, so if you're capturing a mosaic the Vespera could stop imaging mid-way through.
Chris Day, Hillingdon, Middlesex

Recycling in space?

While watching the recent episode of *The Sky at Night* about possible multiverses ('The Multiverse of Mystery'), I wondered if black holes are simply the rubbish or recycling bins of space. What do people think?
Robin Squelch, via Twitter



Mars and two clusters from Dean Noonan

Lining up

I'm fairly new to astrophotography and I love reading *BBC Sky at Night Magazine*. I just wanted to share with you this wide shot of Mars, the Hyades and the Pleiades clusters, which I took on 30 November.

Dean Noonan, Fareham

Worth a wait

I managed to see the lunar occultation of Mars on 8 December, despite the thin cloud in north west England, and I was thinking it must be a rare event to get an occultation at opposition with a full Moon. I've attempted a rough estimate of when this happens and would be interested to know if there are any official sources for future occultations like this, to compare it against. I've worked out that Mars oppositions occur roughly every 26 months, and there is roughly a 1/30 chance of a full Moon, so both things happen together every 26 x 30 = 780 months. According to Google there are 105 Mars occultations every 50 years, which is one every 4,171 hours. This morning's event lasted for exactly one hour, but Mars passed right behind the full diameter of the Moon, so I've assumed that the average occultation lasts half an hour. The probability of an occultation is therefore 0.5 ÷ 4,171, so the frequency of all three events coinciding is approximately once every 780 x 4,171 ÷ 0.5 months, which is about once every half a million years. I'm glad I got up early to watch it now!

Al McDougall, Wigan

Valley views

Characterising gravity by reference to 'valleys' in spacetime – that is, by using an allusion that is itself only meaningful by reference to the everyday understanding of gravity – is a fairly pointless self-referential characterisation, is it not? It is a waste of people's intellectual effort – why not do us all a favour and just delete it?

Matt Bennett, via email

Upgrade & go

Here is a simple upgrade I made to my grab-and-go imaging setup, which is based around a Samyang f/2.0 135mm lens, a Sky-Watcher Star Adventurer mount and a Manfrotto 055 tripod. The upgrade was made using bits that I had lying around and some I purchased online, and the total cost was less than £20. It consists of an electric focuser (an EQ3-2 RA drive motor); a motorised declination axis (EQ3-2 dec. drive motor and gear); and a ▶

SCOPE DOCTOR

Our equipment specialist cures your optical ailments and technical maladies

With **Steve Richards**

Email your queries to
scopedoctor@skyatnightmagazine.com

I'm struggling to keep my Celestron CPC1100 telescope aligned – it gets worse over time and pauses when reversing direction. I'm controlling it with Sky Safari, and there is some backlash. How can I fix these problems?

DANIEL CLARK

▲ **The CPC1100 is a motorised Schmidt-Cassegrain telescope**

As the Celestron CPC1100 mount uses a geared drive system, there is always the propensity for slackness in the gear mesh, resulting in backlash. It sounds like you have backlash in your altitude axis as a minimum, and that your telescope is slightly back heavy. To aid both initial alignment and Go-To accuracy, you should ensure that the telescope is correctly balanced with its accessories installed. Balance can be achieved by disengaging the altitude clutch and manually moving the telescope up and down while checking the balance. Any discrepancy can be compensated for by using a balance bar or magnetic weights. The anti-backlash settings can then be adjusted to give the same value in both positive and negative directions, as described on page 22 of the telescope's manual.

Final movements for alignment should always be carried out by using the up and right buttons on the hand controller, irrespective of the view through the eyepiece.

Steve's top tip

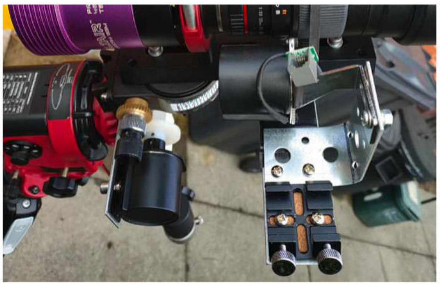
How can I alter my telescope's magnification?

The magnification of a telescope is worked out by dividing the focal length of the telescope by the focal length of the eyepiece in use. So, for example, a telescope with a focal length of 750mm used with an eyepiece of 15mm focal length will have a magnification of 50x.

You cannot alter the focal length of a telescope, but you can change the eyepiece to one with a longer or shorter focal length. With the same telescope, an eyepiece with a focal length of 10mm would yield a magnification of 75x, while an eyepiece with a focal length of 25mm would give 30x.

Steve Richards is a keen astro imager and an astronomy equipment expert


Kevin Rudd's astrophotography setup upgrades



▶ permanent LED light for polarscope illumination. The motors are controlled by the EQ3-2 hand control declination buttons, via a changeover switch. All the upgrades have been done so that they can easily be dismantled to allow the EQ3-2 components to be reinstalled on my EQ3 mount in a matter of minutes, if required. It can also be used with my WhiteCat 51 and Lunt LS50 telescopes, which have helical focusers. The upgraded setup means I can now make fine adjustments without disturbing the mount, but of course there is still the question of automating the right ascension axis. I thought that maybe I could do this by injecting signals into the autoguide port on the mount, but I need to work out how I could do this.

Kevin Rudd, Broughton, Chester

Instagram

astroyyc • 7 December

Here is my first look at the planet Mars coming out of occultation with the Moon! Unfortunately I just barely missed the start (kids swimming lessons!) The seeing was not great through thin cloud. Calgary, Canada 9:01:45 MST @practicalastrophotography @optcorp @bbcskyatnightmag

SOCIETY IN FOCUS

Founded in 1972 in Bletchley by Richard Lambert, **Milton Keynes Astronomical Society (MKAS)** subsequently began meeting in Bradwell Abbey. But in 1997, the society returned to Bletchley for its meetings.

MKAS currently meets fortnightly on Friday evenings at 8pm at Rectory Cottages, Bletchley, or occasionally online. The varied programme ranges from practical astronomy to space exploration, with guest speakers including the Richard Lambert Memorial Lecture, presented annually since 1990. There are also less formal meetings at which members can present results or progress reports relating to their projects, as well as our annual Astroquiz. In addition, our dark sky observation weekends have continued most years, usually in Shropshire, plus social events and trips.

In 2022, MKAS celebrated its 50th anniversary, which included the 'MKAS50 Open Day' on 9 July 2022, an exhibition with demonstrations of daytime astronomy. The official opening was by Councillor Amanda Marlow, mayor of Milton Keynes. There was also a visit by the BBC Three Counties Radio programme *Treasure Quest*.

For more information on what we do and how to get to one of our meetings, visit our website.


JOHN BELL/MKAS

▲ **Members of MKAS with their telescopes at a recent Astromeet**

Mike Leggett, Vice-Chairman, MKAS

▶ **www.mkas.org.uk**

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We pick the best live and virtual astronomy events and resources this month

WHAT'S ON

Winter Nights

Royal Observatory Edinburgh, 14 February, 6:30pm

Tour the Victorian telescope dome and learn about the observatory, plus the science and engineering that goes on there. There will be time for some astronomy and questions too. Children £4.50, adults £7.50.
visit.roe.ac.uk/public-events

Dark Horizons

Online, 2 February, 7:30pm

A presentation from photographer Ollie Taylor on his two-month journey across South America at high altitudes and under clear skies, hosted by Chichester Camera Club, with astronomical and landscape images. £3 for non-members.
chichestercameraclub.org.uk/event

Stargazing at Mugdock

Mugdock Country Park, East Dunbartonshire, 3 February, 7pm

Bring your binoculars, spot constellations and learn facts about space. Venus, Mars and Jupiter may be on show too, and there's an indoor presentation if it's cloudy. £7 plus booking fee. **www.mugdock-country-park.org.uk/things-to-do**

Is There Anybody Out There?

Science Museum, London, 9 February, 7:30pm (doors open 6:45pm)

A discussion on whether we are alone in the Universe, featuring academics from Cambridge University's Leverhulme Centre for Life in the Universe. Tickets £10.
www.sciencemuseum.org.uk

PICK OF THE MONTH

▲ Family fun: enjoy a cosmic journey with a blend of puppetry and storytelling

Journey to the Stars

Neeld Community and Arts Centre, Chippenham, Wiltshire, 15 February, 2pm

The secrets of the Universe revealed, using quirky puppets, props, wigs, fruit and vegetables. The Squashbox Theatre company's show *Journey to the Stars* blends storytelling, live music and comedy with astounding science and astronomy facts. It attempts to answer questions such as what's up there? How far does it go? And does it ever end? A 50-minute show suitable for anyone aged five or over, *Journey to the Stars* attempts to make science and astronomy accessible and fun. £8.50 or £30 for a family of four.
www.chippenham.gov.uk/event/journey-to-the-stars

Hutton Roof spring stargazing

Hutton Roof, Cumbria, 10 February, 7:30pm

Local astronomers – with binoculars and telescopes on-hand – will help to explore astronomical sights under Cumbrian dark skies. Tickets: £20 adults, £15 kids.
www.yorkshiredales.org.uk/whats-on

Planetarium Lates

Glasgow Science Centre, 11 February, 7pm

Taking advantage of the new full-dome digital projection system, this show uses the planetarium dome for a display of spectacular images and the latest ideas in astronomy. Ages 8 and over, tickets £10.
www.glasgowsciencecentre.org

Abingdon Astronomical Society beginners' meeting

Abingdon, Oxfordshire, 27 February, 8pm

A meeting aimed at beginners and novice astronomers, with talks by more experienced society members on the basics of amateur astronomy and an introduction to constellations. No charge.
abingdonastro.org.uk/events

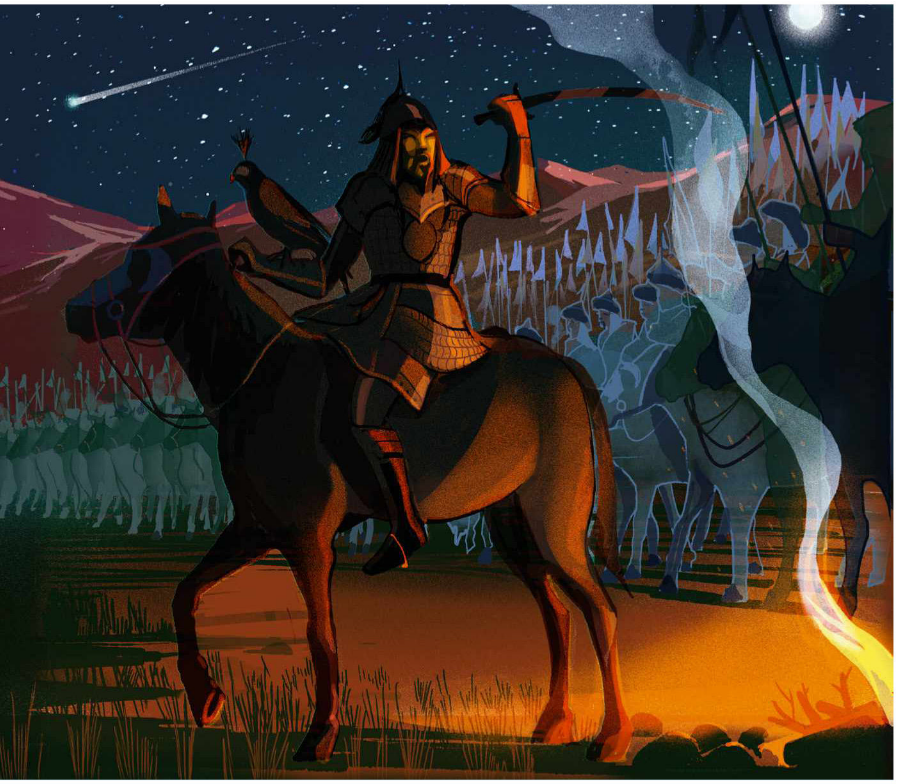
ROYAL OBSERVATORY EDINBURGH, NEELD COMMUNITY AND ARTS CENTRE

The amateur astronomer's forum

FIELD OF VIEW

When the cosmos changes history

Jonathan Powell tracks celestial events that have altered world affairs



ALEX GREEN/FOLIO

Jonathan Powell is a freelance writer and broadcaster. A former correspondent at BBC Radio Wales, he is the astronomy columnist at the *South Wales Argus*

There are those who have been fortunate to experience marvels when looking skyward – a total solar eclipse or the Northern Lights in all their glory – or perhaps they've been lucky enough to find a lens cap on the ground in pitch-dark conditions. However, there are some astronomical showstoppers whose magnificence has gone down in history.

Comets feature significantly in this category down the centuries, such as the Great January Comet of 1910, often referred to as the Daylight Comet, which matched Venus for brightness with its appearance in the daytime sky. Comet Ikeya-Seki dazzled too in the daytime of October 1965, while Comet McNaught also produced a more than decent show, visible in January 2007 in broad daylight.

Well before these more recent showings, we can thumb back through history to 1222. In that year Genghis Khan looked up into the heavens and spotted a blue streak pointing west, which he declared to be his own personal star (it was in fact Halley's Comet). He took the appearance as heavenly approval to sweep his armies through medieval central Asia. So, he did.

Just imagine if an eclipse were to take place during a dramatic battlefield scene, when two great opposing armies were ready to begin manoeuvres. Such an event did occur, when the Medes, an ancient kingdom with roots in modern-day Iran, confronted a neighbouring kingdom to the west in modern-day Turkey, the Lydians. At the Battle of Halys in 585 BC, a total solar eclipse was to stop both warring parties in their tracks. Such was the dramatic impact of the eclipse that peace ensued, with both parties thrashing out a treaty to end hostilities for good.

From a solar eclipse to a lunar eclipse, and none other than Lawrence of Arabia. In 1917, as the Arabs revolted against the Ottoman Empire, Lawrence and his troop of 50 Bedouin soldiers made their way across the desert sand dunes to engage with Ottoman forces holding the city of Aqaba. However, his army was fretful of making a night attack with a full Moon illuminating the landscape. Lawrence, who was aware of the impending lunar eclipse, was able to quell their fears by telling them that there would be no full Moon for a time. He was right and when the eclipse occurred, the Ottoman army were duly spooked, and Lawrence's forces were able to capture the city a short time later.

Despite being widely recorded, supernovae seem not to have had a great influence on historical events, bar the event itself. Looked upon as 'temporary stars', history speaks of two potential occurrences as far back as 185 AD and 393 AD. The first was recorded to have been on view for 20 months, the second for eight months. In subsequent centuries, supernovae have also been recorded in 1006, 1054, 1181, 1572 and 1604, all putting in decent showings, observable for between six months and up to three years.

It's a thought to ponder that these astronomical events, taking place at these great distances, can have such an influence on life here on Earth.

First date with a DSLR

Taking nightscapes and star trails with a DSLR camera is a great way to get started in astrophotography. **Stuart Atkinson** gives his best tips for beginners

The cameras that are built in our smartphones are incredible pieces of technology. Today, many people use their smartphone cameras to capture images of the night sky using 'Night' or 'Low Light' settings, or even dedicated apps. These are great for photos of bright things, such as lunar haloes, planetary conjunctions and bright comets, but eventually anyone wanting to take astrophotos of constellations, nebulae and other celestial delights will have to consider a better option. They need to bite the bullet and buy what many people still consider 'a proper camera' – a DSLR, or Digital Single Lens Reflex camera.

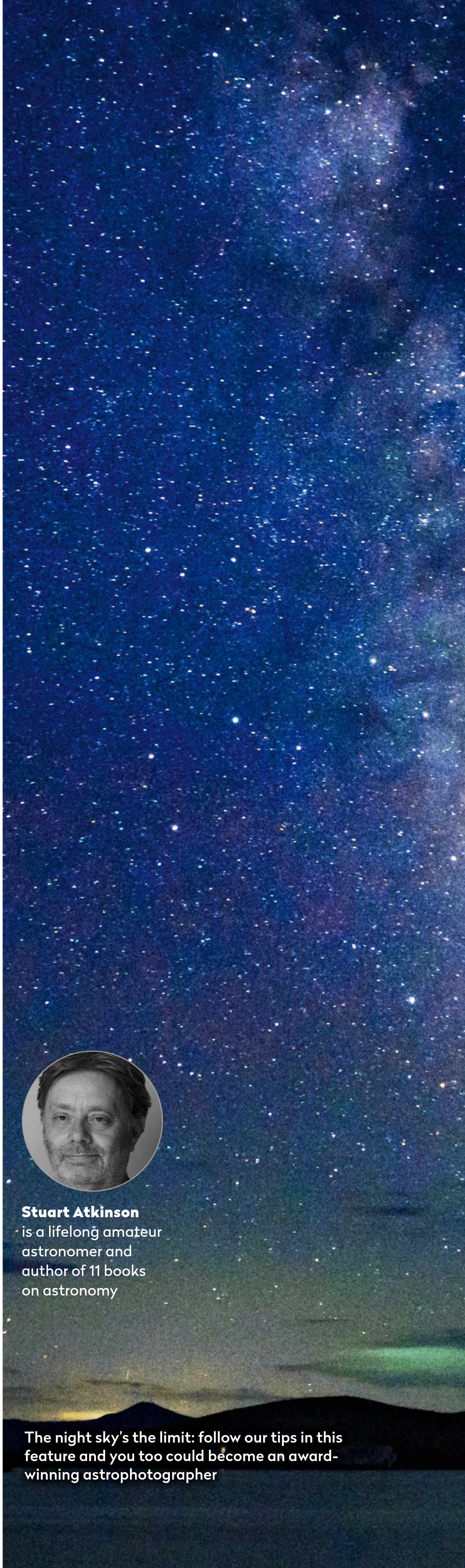
The only problem is, then they have to use it...

This feature is going to take you by the hand and lead you gently through the minefield of taking and processing your very first astrophotos. After that, you can start experimenting with settings and composition to make your photos even better.

There's no better time to make a start, as the Astronomy Photographer of the Year Awards 2023 has just opened for entries. The awards have a special prize for newcomers who have only recently started taking astrophotos – perhaps one of yours could be the one to take home the prize.

But first, let's get started with your first photo! ▶

JASONFANG/OSCAR GUTIERREZ ZOZULIA/ISTOCK/GETTY IMAGES



The night sky's the limit: follow our tips in this feature and you too could become an award-winning astrophotographer

Stuart Atkinson is a lifelong amateur astronomer and author of 11 books on astronomy


Astronomy Photographer of the Year
Astronomy Photographer of the Year 2023 is now open for entries. Turn to page 34 to find out how to submit your photos

Star trails, easy to do, impressive to look at

Setting up your equipment

Getting the right kit is key to getting a good first photo

What will you need to take your first astrophoto with a DSLR? Obviously the most essential thing is a DSLR, and we're going to assume you already have one of those! The make is irrelevant, they all do the same job, which is to collect light on a sensor chip that is turned into an image. You'll also need a memory card in your camera. This sounds obvious but trust me, you don't want to be standing in the middle of a field in the dark and see the words 'No Memory Card In Camera' appear on your screen because you left it at home – not that I've ever done that, of course!

If you use your DSLR for daytime photography you've probably got several lenses, but which one should you use for taking your first astrophoto? The 18-55mm 'kit lens' or standard 50mm lens that came with your camera will be fine. Don't use anything 'bigger' than 50mm yet.

You will need to have a good tripod to mount your camera on, because (despite what some people will tell you) you just won't get the same results from pushing your camera down into a bean bag or rolled-up jumper plonked on the top of your car. A remote shutter release is highly recommended, but not essential. Take along the red flashlight or head torch you use when you're out stargazing. If you don't have one, install a 'Red Light' app onto your phone.

Lastly, but very importantly, you'll need a good location to take your photos from. If you're restricted to your back garden that's fine, you can still take pictures, but if you can get away from all the streetlights, security lights and illuminated shop signs to a dark-sky site, those pictures will be much better.

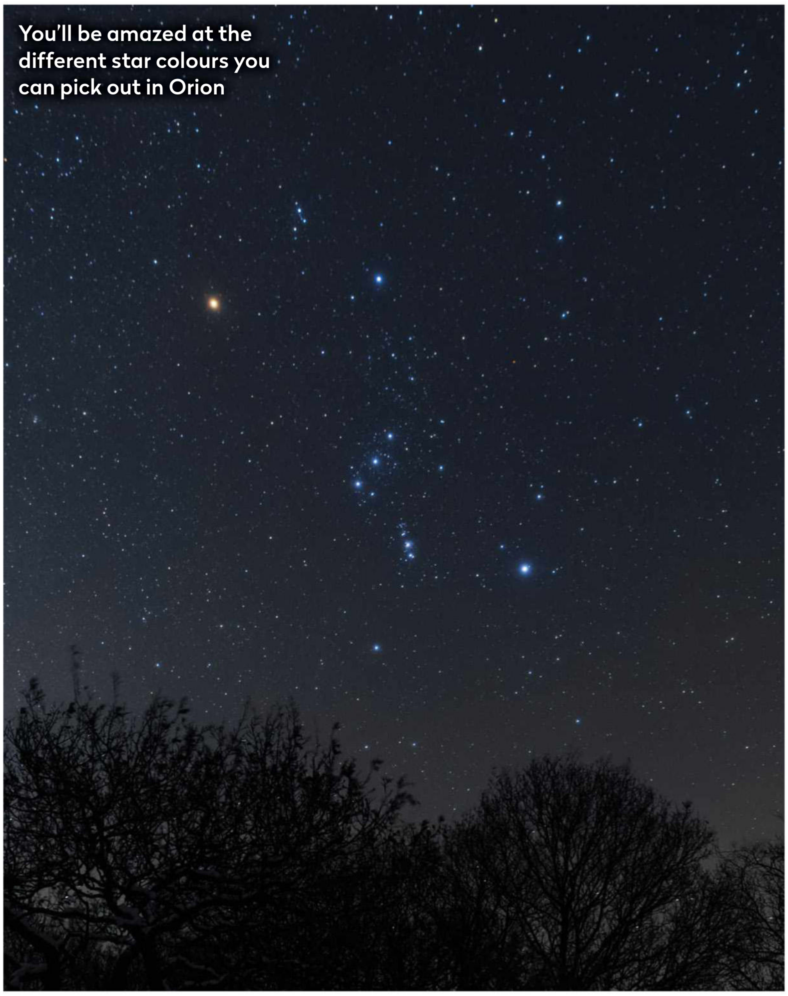
MATTEO COLOMBO/ISTOCK/GETTY IMAGES, STUART ATKINSON, WILL GATER X 3

Try to avoid ambient light sources that can interrupt your night shoot

Make sure you've got all the kit you need when you get started

Taking your first astrophoto

Bright constellations like Orion are a great target to get started



You'll be amazed at the different star colours you can pick out in Orion

One of the aspects of astrophotography that newcomers find most difficult is focusing their camera. It's easy photographing a friend's wedding reception, or your sleepy kitten in the daytime, but the first time you try to focus your camera on the night sky you'll probably want to throw it into the bushes in frustration. Finding focus is actually quite easy once you know how. First, take off the lens cap (personal tip here: get into the habit of always putting lens caps into your left pocket, think 'Left for Lens', so you won't forget where they are). Next, set your camera focus to 'Manual' instead of 'Auto Focus' and then point it at a streetlight or a light on the side of a distant building – not a star. Focus on it roughly using the viewfinder, then use the 'Live View' feature on your camera screen to fine tune the focus until it's sharp. Now swing your camera towards a bright object in the sky – perhaps the star Sirius, or the planet Mars, both of which will be prominent as you read this – and use 'Live View' to focus as sharply on it as you can. After that, leave it alone.

Next, aim your camera towards the constellation of Orion, centred roughly on Orion's Belt. Don't worry about framing, or foregrounds, you're just trying to photograph some stars this very first time. When you can see stars clearly on your camera screen, set its 'Mode' to 'Manual' by turning the appropriate dial, or selecting it from a 'Settings' menu. Next, set your camera's ISO (which mimics the film speed of film cameras) to 1600. Then set the 'Exposure Time' to 15 seconds if you're using a wide-angle kit lens, or 4 seconds if using a standard 50mm lens.

There's just a few more tweaks and you'll be ready. Set a 'Time Delay' – around 3 seconds or 10 seconds, depending on the make of your camera – as this will give a few seconds to reduce vibrations after clicking the camera's shutter, keeping your stars as points of light instead of squiggles. Alternately, if you have one, use a remote shutter release to take the picture without touching the camera.

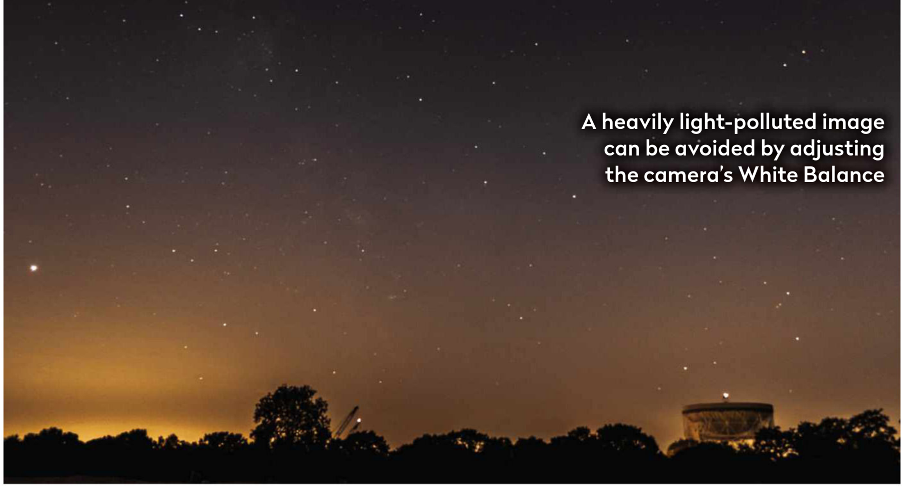
Finally, set the 'Image Format' to 'RAW' if you want, but it's not essential at this early stage, no matter what some people may tell you. RAW format images record more information, so give better processing results, but it's perfectly fine to just stick to JPEG format on the first night if you're more comfortable with that (or you just forget).

Then take a deep breath and push the button to take your first photo.

It will feel like time has stood still as your camera drinks in all the starlight, but eventually you'll hear a click telling you it's finished. If everything worked you'll have just taken your first astrophoto, so take a look on the preview screen. If a wide-angle lens was used all of Orion will be on it, while a 50mm lens won't quite get all of it. If it's a little wonky, don't worry, it doesn't matter – this is just your first try. Just look how many more stars are on it compared to pictures taken with your phone camera, and how colourful they are. How cool is that? Congratulations! ▶

▲ **Get into the habit of setting your camera's ISO to 1600 for a colourful wide-field shot of Orion**

▲ **Using a remote shutter release is a great way to ensure there is no camera shake on your images**



A heavily light-polluted image can be avoided by adjusting the camera's White Balance

Taking better photos

If your first attempt doesn't work, there's plenty of things to try

There are several common problems that might crop up on your first astrophoto. If your image is too dark, increase either the ISO or 'Exposure Time'. If your image is too bright, decrease either the ISO or 'Exposure Time'. If your stars look like squiggles something moved during the exposure, so tighten everything up, especially on your tripod. If your image looks orange, change the 'White Balance' from sunlight (a 'Sun' symbol) to artificial light (usually a symbol that looks like a 'Lightbulb' or a strip light), which will get rid of the orange cast produced by light pollution.

Now try again – your second photo should be better than your first.

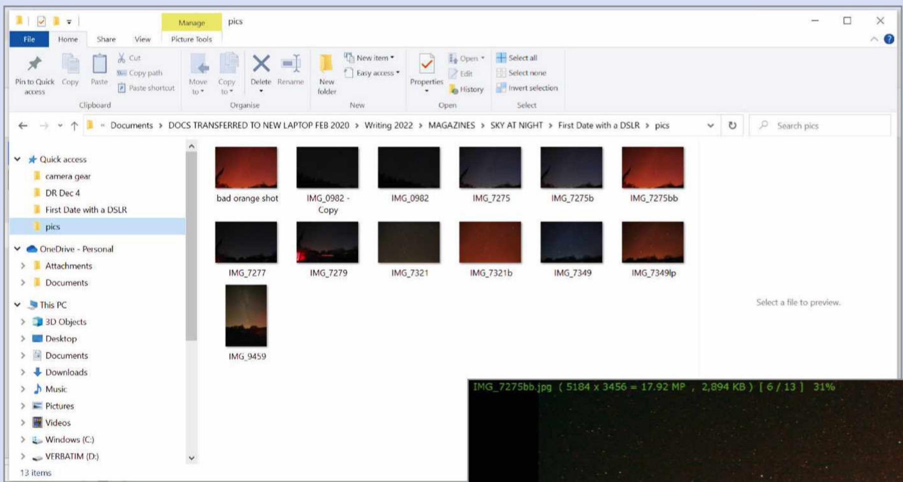
Then keep going. Try a variety of different ISOs and exposures, just to see the difference that changing these basic settings makes. When you have found a selection of settings that collectively give you good images, stick to it. Leave Orion and try imaging different parts of the sky, maybe Mars, or Sirius, or Cassiopeia – it doesn't matter which. You've done the hard part, now it's time to just experiment and have fun!

Processing your first image

A little experimentation can give great results

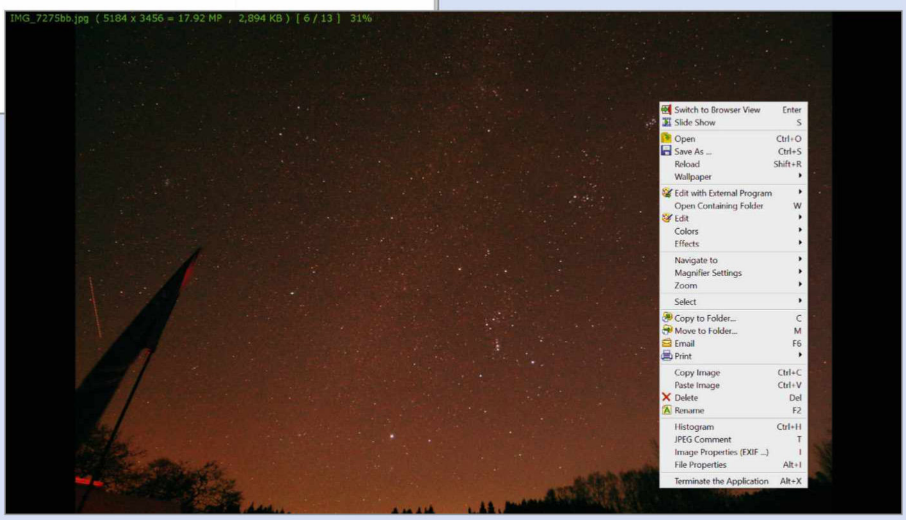
Having taken your first images you need to get them off your camera and into a computer if you want to see them, improve them and share them with others. This is called processing and getting started can be quite daunting, so we're just going to look at the absolute basics here. Follow these, and you're on your way to creating incredible astrophotos. You will need:

- ▶ A USB card reader to insert into your computer, or its card-reading slot
- ▶ The memory card from your camera
- ▶ Image processing software on your laptop



◁ Step 1

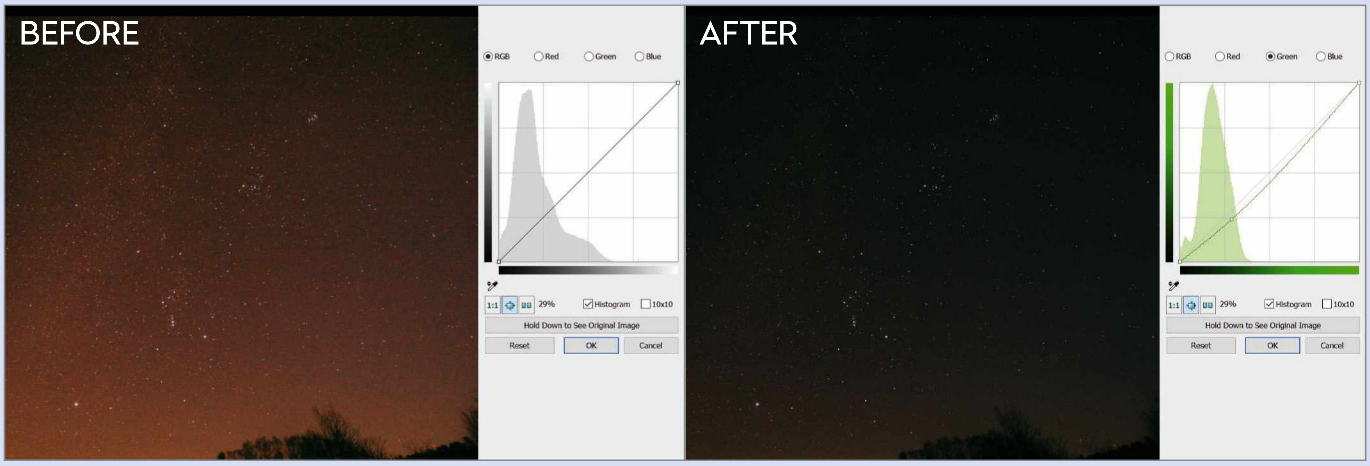
Remove your camera's memory card and insert it into your computer's in-built card reader, or an external one. Find the relevant external drive folder and click on it to locate your images. We recommend that you change the settings on your computer so images show as pictures, not just meaningless file names.



Step 2 ▷

Open your image-processing software and import one of your images. On the screen your image won't look as bright or as detailed as it did on the back of your camera, but don't panic! You were looking at a high-contrast version, in the dark, on a bright screen. Once enlarged it will look less punchy, but the processing will change that.

1298073728/ISTOCK/GETTY IMAGES, STUART ATKINSON X 6

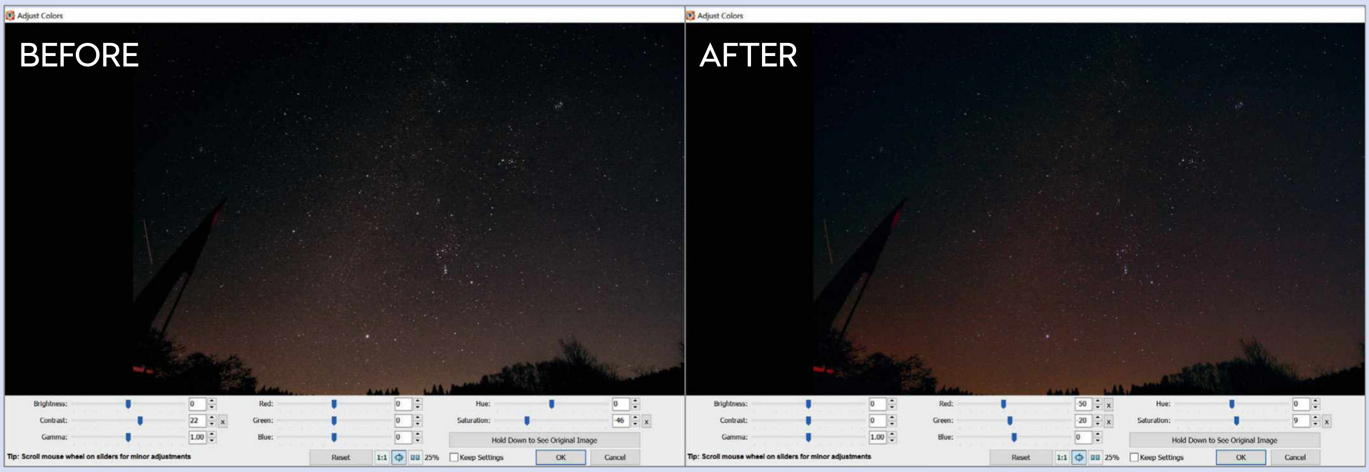


△ Step 3

First, use the 'Curves' function to change how your image looks. Experiment by moving the curve around to adjust the brightness and contrast until it looks better. Don't go overboard – remember that less is more when it comes to astro image-processing. You can always undo your work if you go too far.

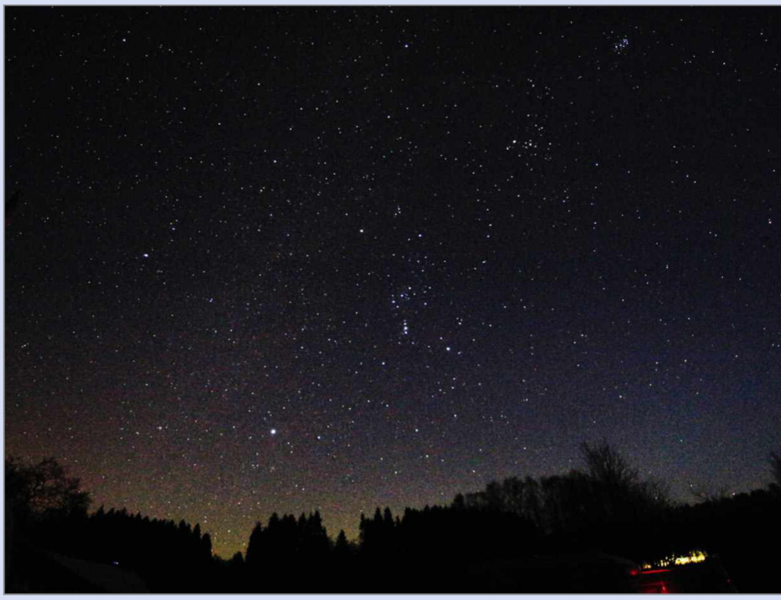
▽ Step 4

Use the 'Saturation' function to change how colourful your image looks. If the colours of the stars are too garish you can reduce that, or if they are too bland you can boost them. But again, don't go mad or you can end up making the stars too bright and blown out.



▽ Step 5

Use the 'Sharpen' function to make your image clearer, especially if your focus wasn't as sharp as you thought it was. If you used RAW format when shooting, your images will look a lot cleaner than JPEGs, but at this stage that's not too important.



△ Step 6

When you have a processed image you're happy with, create a new folder on your computer – put the date you took your images in the title to help you find them again – and export your image into it. Use 'Save As' to create a new file with its own name, leaving the original on your memory card for now. You might want to go back to it later.

Astronomy Photographer of the Year

Supported by Liberty Specialty Markets

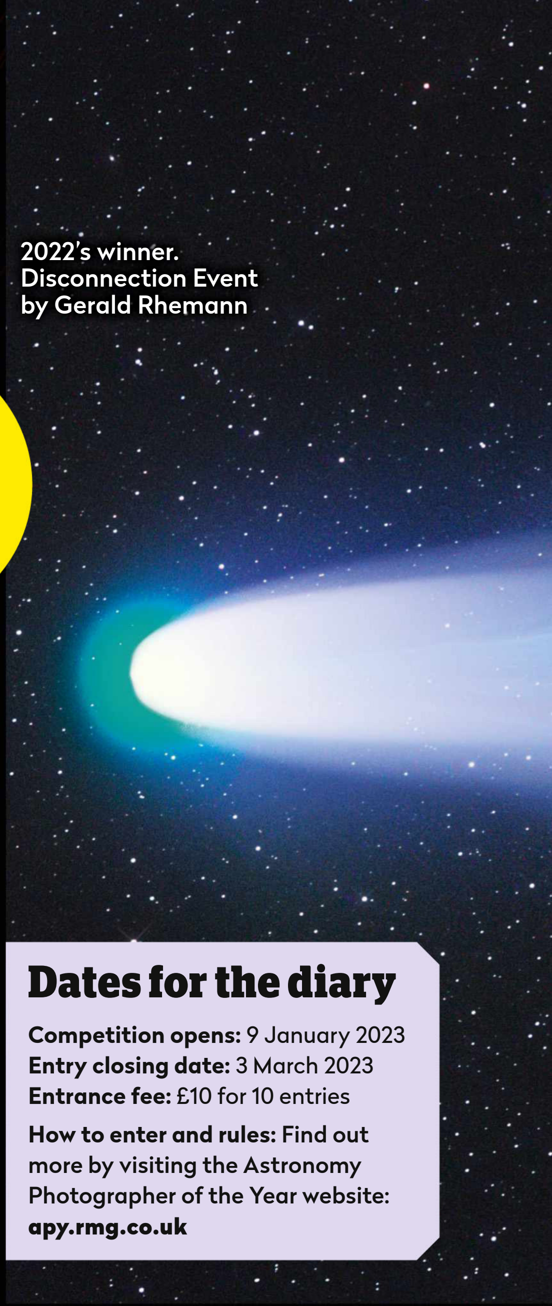
OPEN FOR ENTRIES!

The world-class competition returns in 2023, seeking the best astronomy image of the past year

The time has come again for astronomy photographers around the world to put the finishing touches to their best images in the hopes of being named the winner of the 2023 Astronomy Photographer of the Year competition, supported by Liberty Specialty Markets. The world's biggest astrophotography competition is now open for entries from astrophotographers hoping to win the grand prize of £10,000.

Now in its 15th year, the competition has eight main categories for different astronomy subjects, each with a £1,500 prize up for grabs, as well as runner-up and highly commended awards of £500 and £250 respectively. There are also two special prizes of £750 each: one for the best newcomer, and one for using professional data in an innovative way.

Entrants under 16 years old can enter the Young Astronomy Photographer of the Year competition in the hope of winning £1,500, as well as a Celestron Astromaster 130EQ MD to help them continue their observations of the night sky. So no matter what your experience, age or area of interest, there's a category to suit you. An exhibition of the winning images will be on show at the National Maritime Museum, London, from 16 September 2023. Below are #APY15's 11 categories. You can enter each one multiple times:



2022's winner. Disconnection Event by Gerald Rhemann

Dates for the diary

Competition opens: 9 January 2023
Entry closing date: 3 March 2023
Entrance fee: £10 for 10 entries

How to enter and rules: Find out more by visiting the Astronomy Photographer of the Year website: **apy.rmg.co.uk**

Planets, Comets and Asteroids

It's been a great year for Solar System observers, with a parade of planets visible as well as a number of bright comets. If you managed to get a good astrophoto of one of our planetary neighbours, enter it into this category.

Aurorae

The Northern and Southern Lights are some of the natural wonders of our world. Capturing their beauty requires persistence, skill and luck, so if you were fortunate enough to capture a striking aurora shot, you could take this hotly contested prize.

People and Space

Stargazing is a unifying experience, linking the world as we all look up at the same sky. This category explores that connection, asking for images that show the impact of humanity juxtaposed against the vast Universe.

Skyscapes

The night sky can often seem remote, unconnected to us on the ground. This category aims to showcase landscapes or cityscapes alongside celestial objects in the same scene, and is one of the contest's most popular.

Our Moon

Our nearest neighbour is a wonderfully varied world. The craters and crags of the Moon's surface offer opportunities for close-up imaging, while its changing phases showcase the clockwork motion of our Solar System in action.

Our Sun

Cutting through the intense glare to photograph our Sun takes skill, but the results can be striking and dynamic. Last year gave a host of photo opportunities, with huge solar flares and sunspots sighted as activity ramps up.

Stars and Nebulae

To our eyes, the stars are points of light, but a telescope reveals many of them are embedded within dusty clouds of nebulae. It is only astrophotography that can truly pull out the fantastical colours and intricate structures of these faint objects.

Galaxies

No other celestial object showcases the vastness of the Universe as much as galaxies do. Collecting the light from these distant targets and then processing the captures to look their best is a real challenge, requiring great skill in astrophotography.

Young Astronomy Photographer of the Year

Many astrophotographers start the hobby at an early age, but that youth doesn't mean their work is any less deserving. This special competition is open to any entrants under age 16, to showcase and encourage the great photographers of tomorrow.

Special Prize: Patrick Moore Prize for Best Newcomer

Don't assume that you need high-end equipment and years of experience to get started in astrophotography. This special prize aims to encourage those who are new to the hobby and give their work a chance to shine.

Special Prize: Annie Maunder Prize for Image Innovation

The night sky should be open to all. This special prize asks entrants to process data from professional observatories in an innovative way – whether that's creating false colour images, arranging it in a novel way, or creating a physical object using the data.

Chelyabinsk 10 years on

In 2013 **Ezzy Pearson** visited the site of a massive meteor explosion. A decade later she looks back at what we learned from the event

At 9:20am on 15 February 2013, the people of the industrial town Chelyabinsk in Russia were starting their mornings when a light streaked across the sky. Bright enough to outshine the Sun, people ran to windows to see the trail it left in the sky. A few minutes later, a boom swept through the town, shattering windows, bringing down walls and knocking people to the ground.

That shocking sound was a meteor exploding overhead, but it wasn't just the noise. Fragments of rock were blasted across the landscape by the blast, falling down on the snow like rain.

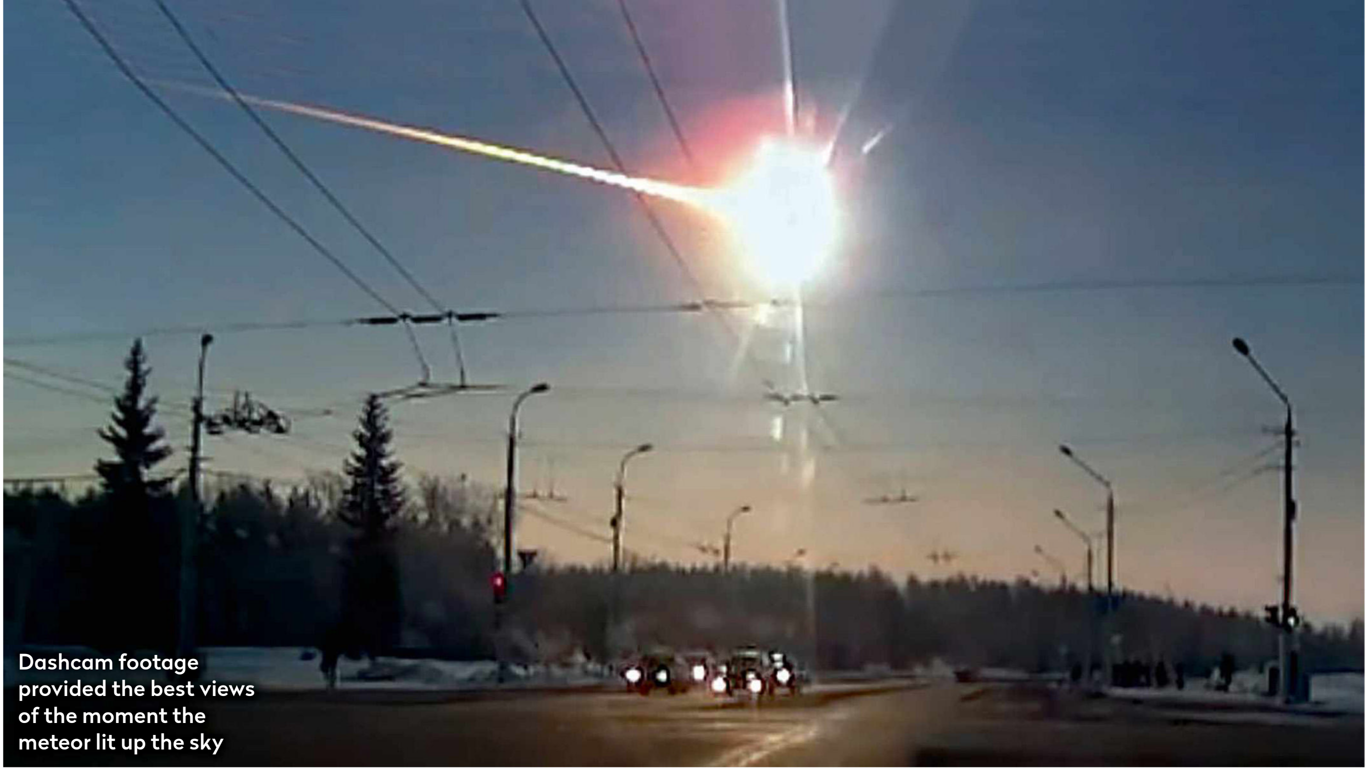
Videos from dashcams and CCTV cameras soon appeared on news channels around the world, sending meteorite hunters and researchers flocking to the town. Among those who arrived after the airblast was a young PhD student just getting started in her journalistic career – me.

I'd been asked to present a documentary about the event with the rather dramatic title of *Meteor Strike! Fireball from Space*, which was how a film crew and I found ourselves knee-deep in snow during the Russian winter, three weeks following the explosion. However, it was the very snow freezing my toes that made Chelyabinsk the perfect place for a meteorite hunt. When the rocks fell onto ▶

ULLSTEIN BILD/GETTY, EZZY PERASON

The dramatic trail of smoke left by the Chelyabinsk meteor when it exploded

Ezzy in Russia during filming for the 2013 documentary *Meteor Strike! Fireball from Space*



Dashcam footage provided the best views of the moment the meteor lit up the sky

▲ A 6m-wide hole in the ice covering Lake Chebarkul, discovered after the meteor exploded, was where its largest fragment fell to Earth and was later recovered

▶ untouched snow, the heat they picked up from their journey through the atmosphere melted a clear, obvious hole. Find a hole, dig to the bottom and there's a good chance you'll find a meteorite.

The area had been picked over by the time we arrived, but our director did manage to find a 1cm wide pebble. It was pure black, covered in a fusion crust created by the heat of entry melting the surface. There's something magical about holding a freshly found meteorite in your hand. This was a fragment left over from the birth of the Solar System. It had been in space for billions of years until just a few weeks ago. And by this point, there was even a pretty good idea of where it had been.

"When a fireball is sighted in the sky, as was the case with Chelyabinsk, camera footage helps scientists to calculate where in space the rock might have originated – though this evidence isn't usually enough on its own to know for sure," says Natalie Starkey, a geologist and author of *Catching Stardust: Comets, Asteroids and the Birth of the Solar System*.

Social media provided a wealth of camera footage, which planetary sleuths – both professional and amateur – had already set to work analysing, measuring the motion of the meteor and the shadows it cast, then comparing them to Google Maps. It appeared that the meteor had hit the atmosphere at a shallow angle, travelling around 65,000km/h. Any large pieces that survived would have come down around nearby Lake Chebarkul – where a 6m-wide hole in the ice had already been found. Tracking the path back suggested that the meteor had probably been in an elliptical orbit, taking it from beyond Mars to almost the orbit of Venus, before striking our planet.

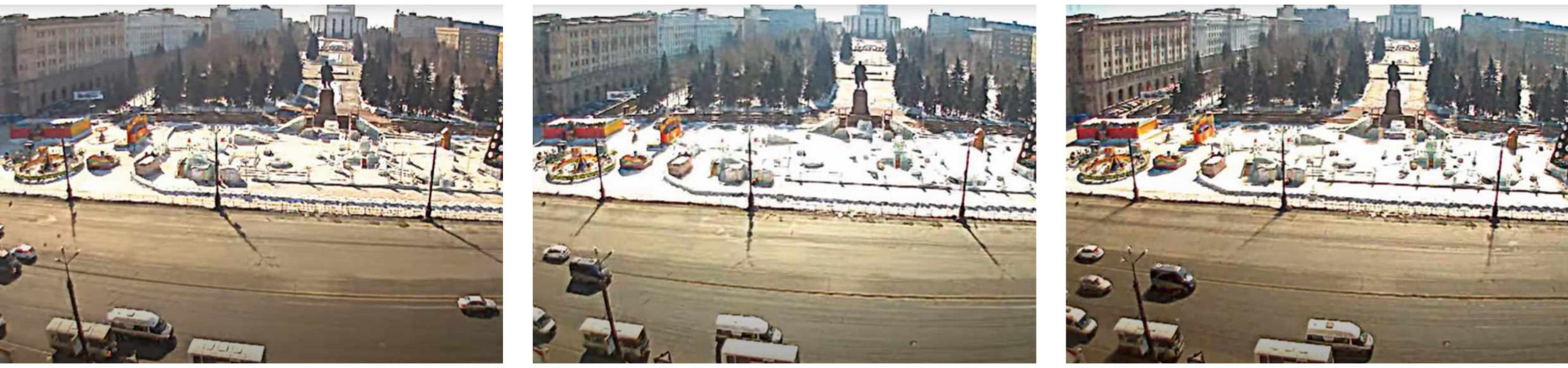
Collecting data

Another unusual source had recorded even more data: infrasound stations, which normally listen out for tests of illegal nuclear weapons, had picked up the explosion as far away as Antarctica. These measurements indicated that the blast, at 500 kilotons, was 30 times more powerful than the bomb detonated at Hiroshima, which allowed them to estimate that the asteroid which struck the atmosphere had a mass of around 130,000 tonnes.

"That suggests the meteorite was around 20m in diameter, roughly the length of two double decker buses end-to-end. This is actually quite a small chunk of space rock, but it's still extremely lucky it broke up into smaller pieces," says Starkey.

The infrasound recordings actually detected seven separate explosions, occurring between 83km and 30km in altitude. While making the documentary, I'd discovered the reason for its repeated fractures first-hand when we arrived at the Ural Federal University in Yekaterinburg, a few hours' drive from Chelyabinsk. Their geologists had sent their own meteorite hunters to amass a sizable collection of meteorites, several of which had already been sliced up for closer examination. I didn't envy that task, as the rocks were remarkably fragile. Pieces crumbled off as you handled them, so it was no surprise the larger rock hadn't made it to the ground in one piece.

"Our atmosphere does a good job of slowing down space objects before they reach the surface of our planet," says Starkey. "It's not exactly like



▲ **CCTV footage of the movement of shadows caused by the bright light of the meteor helped internet sleuths plot its trajectory**

▲ **Ezzy holds a 1kg sample of the meteorite (left), before examining it under an electron microscope (right)**

hitting a wall, but this deceleration results in the rock experiencing high temperatures and pressures, which can blow the meteor to pieces as all the heat and kinetic energy are released in an instant."

Looking at the meteorite samples under an electron microscope revealed the Chelyabinsk meteor was an ordinary chondrite, the most common type of space rock found on Earth. These are stony meteorites made up of dust and grains called chondrules which were never incorporated into planets, meaning they represent the primal material from which the Solar System was built.

Further studies

Unfortunately, I only got a brief glimpse of the work being done before having to return home, but geologists around the world continued to study the rocks. On 16 October 2013, the collection got its biggest addition when a 540kg chunk was raised from Lake Chebarkul. In the years after, dozens of papers were released about the fireball, covering everything from the meteorite itself to the response of the emergency services. Together these built the picture of a space rock that had once been part of a larger asteroid in the belt between Mars and Jupiter, but at some point had been chipped off and sent on its fateful journey towards Earth.

Over time, the other falls were discovered and the Chelyabinsk meteorite samples became one of ▶

Defending the planet

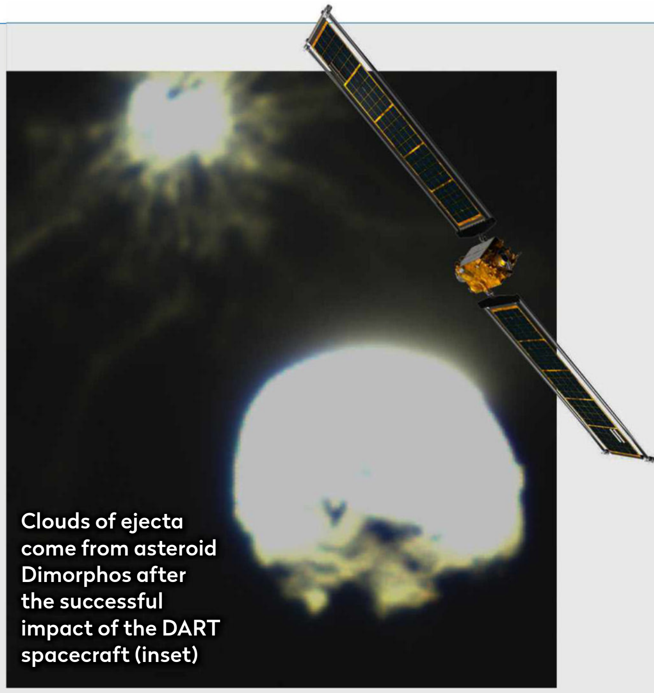
Meteors pose a risk to our planet, but humanity is ready to fight back

As well as a science opportunity, Chelyabinsk was a wake-up call to the dangers of meteor strikes. 1,500 people were injured by the blast, though most of these were from debris and glass sent flying by the shockwave, or sunburn from the bright light.

However, Chelyabinsk was a small asteroid over a small city. If the fireball had exploded over the skyscrapers of London or New York, it would have been a different story.

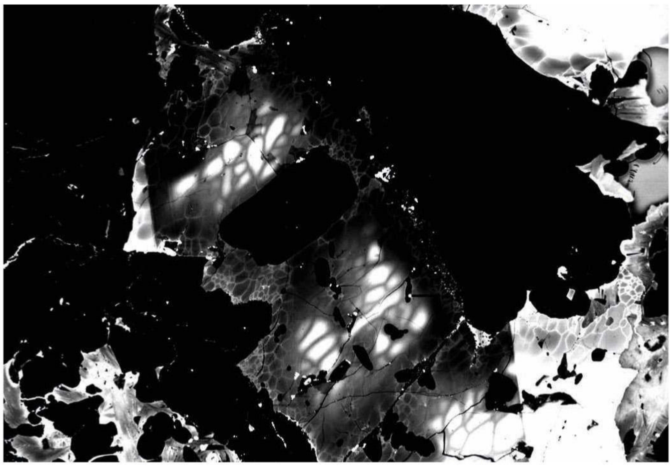
The last decade has seen many measures taken to prevent such a disaster. Surveys have tracked down 95 per cent of asteroids over 1km, the so-called 'planet killers'. The remaining asteroids are hidden by the Sun's glare, the same reason that the Chelyabinsk meteor wasn't seen ahead of time. However, four of these were tracked down in November 2022, and other surveys are working on finding all the near-Earth asteroids down to 140m in size.

Meanwhile, NASA's DART mission demonstrated we have the technology to deflect an oncoming asteroid, meaning we are more equipped than ever to defend ourselves from killer space rocks.



Clouds of ejecta come from asteroid Dimorphos after the successful impact of the DART spacecraft (inset)

UNIVERSITY OF CAMBRIDGE DEPARTMENT OF EARTH SCIENCES X 2, NASA/GODDARD/UNIVERSITY OF ARIZONA, MARK GARLICK/SCIENCE PHOTO LIBRARY/ALAMY STOCK PHOTO, LUMACA



▲ A Cathodoluminescence (CL) image of the Chelyabinsk meteorite, taken by a scanning electron microscope at a scale of several hundred micrometres, reveals crystals containing uranium and lead

▲ Craig Walton, from the University of Cambridge's Department of Earth Sciences, prepares meteorite samples for analysis on a scanning electron microscope

▶ many in the catalogues (though my own small meteorite has always had pride of place on my desk). Yet there was still one outstanding, and niggling, question that researchers hadn't reached a satisfactory consensus about. When had the impacts that shattered the asteroid occurred?

"There was a debate about whether there were dozens of impacts or just one," says Craig Walton from the University of Cambridge. It was a debate that he has spent the last six years trying to resolve.

"I first laid hands on the meteorite in 2016, when I did a summer research project at the Open University," says Walton. "Chelyabinsk is one of the oldest rocky objects in the Solar System. It's experienced a tumultuous history out in space and records a complicated history of collisions, but people hadn't revealed the exact sequence of events."

Rock of ages

This history is written in the dark veins that run through the Chelyabinsk meteorites. These are shock melts, created by the intense heat of a collision melting the rock unevenly, meaning the date of their origin shows when an impact occurred. Walton

Bringing space rocks home

Meteorites and samples taken directly from asteroids are valuable to planetary science

Rather than waiting for meteorites to come to us, on 24 September 2023 the OSIRIS-REx spacecraft will return to Earth with a pristine sample of space rock taken directly from an asteroid.

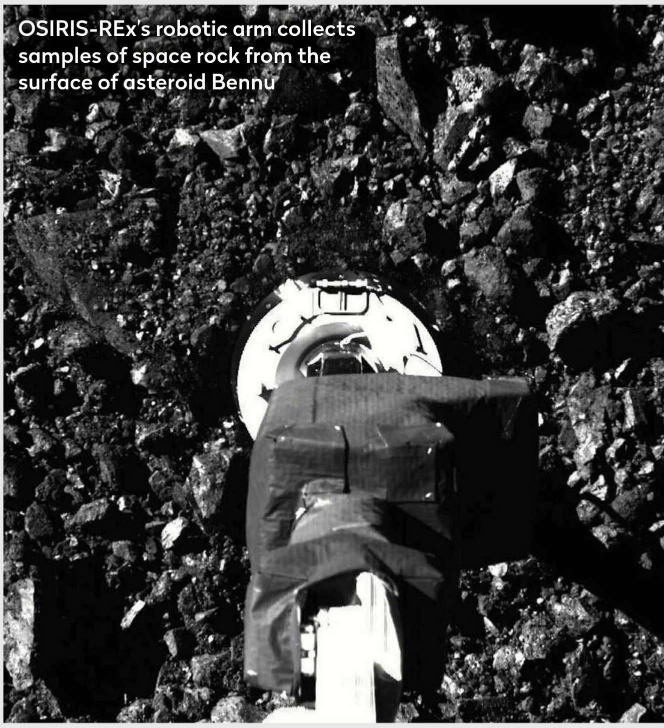
"The wonderful thing about pristine material is that it didn't have to pass through our atmosphere in a violent way – everything recorded by the sample is about what happened to the asteroid," says Craig Walton from the University of Cambridge.

The extreme journey through the atmosphere causes its own changes, adding a layer of obscuration that planetary scientists have to get past. They are also contaminated at the moment they hit the atmosphere, meaning it's impossible to know if traces of organic compounds in the sample were originally part of the asteroid or picked up while on Earth.

"If you're interested in discovering what asteroids brought to Earth that's relevant for life, you need a pristine sample," says Walton.

However, they are expensive, take a long time and return just a few grams of material. The only mission to successfully return material to Earth, Hayabusa2 in 2020, took six years to bring back just 5g of material. Meanwhile, facilities like the Open University and Natural History Museum have huge catalogues of meteorites.

"They will forever be an invaluable archive, although they're complicated and challenging to understand," says Walton. "We're just not going to be able to go to every asteroid in the Solar System and bring back lumps of each. But meteorites are doing the job for us."



OSIRIS-REx's robotic arm collects samples of space rock from the surface of asteroid Bennu

ILLUSTRATION

One theory suggests that the origins of the Chelyabinsk meteorite can be traced to rocky debris from the collision that created the Moon

thought the key to their age might lie in the uranium within the melts. The element radioactively decays to lead, and while the rock is cool, both of these remain trapped in the crystal structure of the rock. When it's heated up, however, the lead escapes while the uranium stays put.

"Based on the fact that we know the half-life of uranium to lead, we can tell how long the crystal has been cold for by measuring the ratio of these two, essentially taking the time since it was last in an impact," says Walton.

Getting the data, however, ended up taking six years, in part due to COVID-19 shutting down laboratories in the UK.

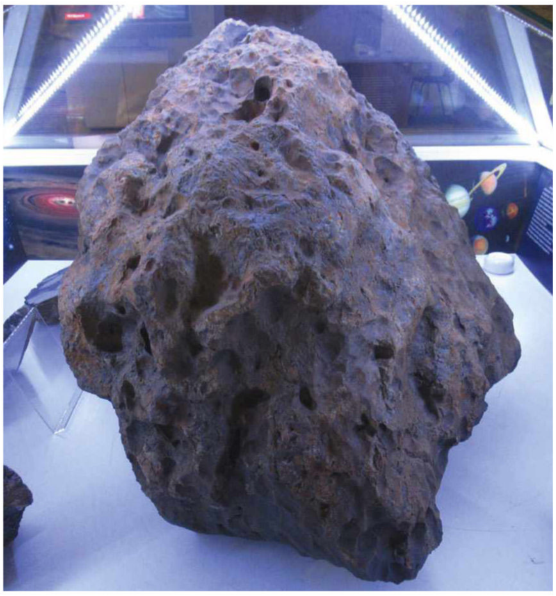
"I ended up sending the precious samples I had spent years looking at to Beijing," says Walton. "It got impounded at customs for a month."

Eventually the samples made it and the test results showed two distinct ages or events. The most recent impact, which chipped the asteroid from its parent rock and sent it towards Earth, appears to have occurred within the last few million years. But there was another event 4.45 billion years ago – around the time our own Moon was created.

"Chelyabinsk is not the only meteorite to report a big collision at this time," says Walton. "One interpretation is that the massive collision that formed the Moon created debris, some of which was flung around the Solar System and struck asteroids. The other possibility is the planets were undergoing a final episode of reorganisation and the gravitational effects caused asteroids to bump into each other."

In the coming years, other researchers will no doubt return to the meteorites to confirm or deny Walton's findings, or look for other pieces in the puzzle of our Solar System's creation. Though the meteorites might be one of the most common types, it is undeniably unique. Its age means it has recorded a long swathe of planetary history and more is known about its journey through the atmosphere than any other space rock. Add to that the huge quantity of meteorite material recovered, and there's no doubt that the Chelyabinsk meteor will keep planetary geologists curious for years to come.

"It is right at the forefront of piecing together the Solar System's history using meteorites," says Walton. "If you can explain Chelyabinsk, maybe you can explain everything else."



▶ **The largest fragment of the meteorite to be discovered so far, with a mass of 540kg, on display in Chelyabinsk**

Ezzy Pearson is *BBC Sky at Night Magazine's* features editor. Her book *Robots in Space* is available through History Press

16-PAGE CENTRE PULLOUT

BBC Sky at Night MAGAZINE

The Sky Guide

FEBRUARY 2023

THE EASTERN SEA

Libration reveals a view of the Moon's Mare Orientale mid-month

VISITING VENUS

The Moon, Jupiter and Neptune all pop in on the 'Evening Star'

CATCH THE COMET

Observe C/2022 E3 ZTF all month

PETE LAWRENCE

About the writers

Astronomy expert **Pete Lawrence** is a skilled astro imager and a presenter on *The Sky at Night* monthly on BBC Four

Steve Tonkin is a binocular observer. Find his tour of the best sights for both eyes on page 54

Also on view this month...

- ✦ Try to spy the Pup Star
- ✦ See Fra Mauro, where Apollo 14 landed
- ✦ Doggy treats: tour the sparkling sights near Canis Major

Red light friendly

To preserve your night vision, this Sky Guide can be read using a red light under dark skies

Get the Sky Guide weekly

For weekly updates on what to look out for in the night sky and more, sign up to our newsletter at **www.skyatnightmagazine.com**

FEBRUARY HIGHLIGHTS

Your guide to the night sky this month

Thursday 2

Naked-eye comet C/2022 E3 ZTF is located 5° southeast of the magnitude +4.2 open cluster Collinder 464 in Camelopardalis this morning.

◀ Sunday 5

Today's full Moon occurs near apogee – known as a 'micromoon'.

Mars and Aldebaran (Alpha (α) Tauri) have a conjunction in right ascension, Mars 8.2° north of the star.

Wednesday 8

This evening and into tomorrow morning, still just clinging onto naked-eye visibility, mag. +5.6 comet C/2022 E3 ZTF is less than a degree west of mag. +2.7 Hassaleh (Iota (ι) Aurigae).

Thursday 9 ▶

As the Moon moves out of the way, now is the time to try our Deep Sky Tour on page 56. This month we're looking at objects in and around Orion's Sword.

◀ Sunday 12

Follow our Moonwatch target (see page 52), Fra Mauro and craters around it (Bonpland and Parry pictured) this morning through to the morning of 14 February.

Monday 13

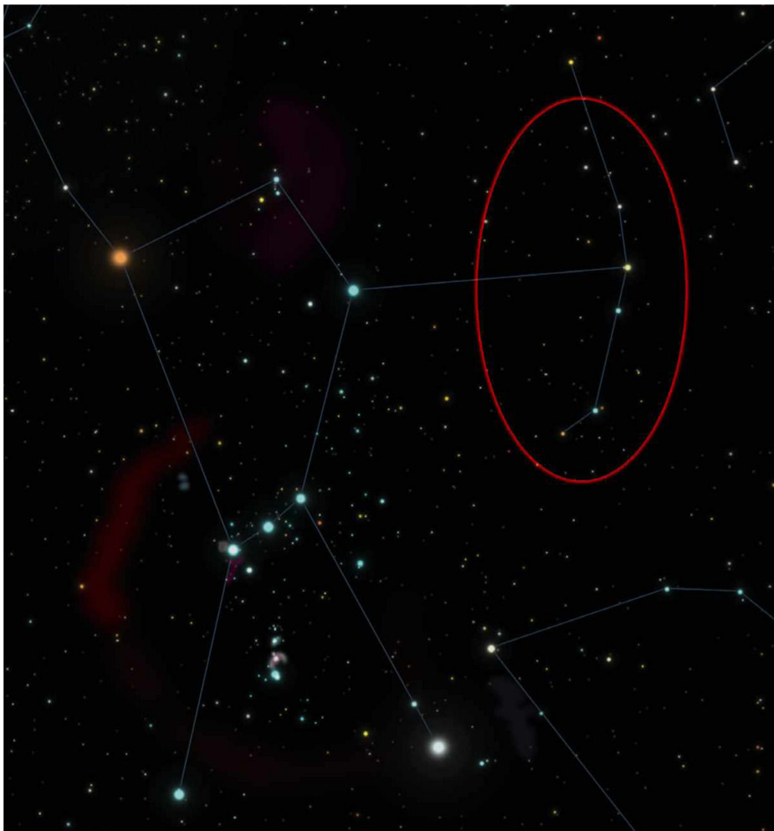
Comet C/2022 E3 ZTF passes just west of the mag. +6.4 open cluster NCG 1647 in Taurus this evening. The cluster and comet are located east of the Hyades open cluster.

Thursday 16

A fairly favourable libration of the Moon can be seen today, tilting the western limb towards Earth. This provides a good view of features such as the Mare Orientale.

Saturday 18 ▶

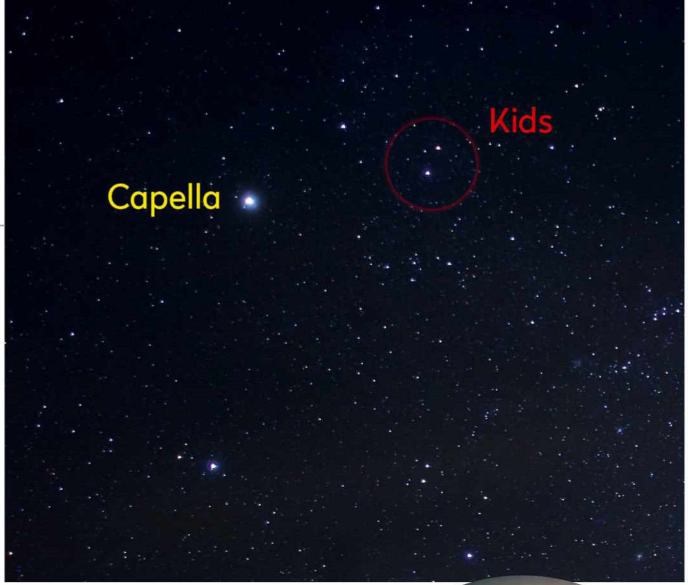
Fading comet C/2022 E3 ZTF is travelling on a southward path west and roughly parallel to the faint but distinctive line of stars formed by Pi[1] (π[1]) to Pi[6] (π[6]) Orionis.



Family stargazing

Bright planets Venus and Jupiter are easy to find in the evening twilight, low in the west after sunset. Wait for the Sun to properly set then set a task: who can spot the planets first? If the weather is reasonable, aim to start looking on every available evening from 20 February through to 10 March. It's unlikely they will all be clear though. Suggest drawing the arrangement seen on each evening using a finger held out at arm's length for scale. The Moon will join the scene around 21–23 February, adding a bit of extra excitement. **bbc.co.uk/cbeebies/shows/stargazing**

PETE LAWRENCE X 7



Monday ▶

6 This evening and into tomorrow morning, mag. +5.3 comet C/2022 E3 ZTF is heading south past the Kids asterism in Auriga, a pattern representing baby goats.

Saturday ▶

11 The period from this morning through to tomorrow evening sees sixth-magnitude comet C/2022 E3 ZTF having a close encounter with Mars. See pages 46 and 53.

Tuesday ▶

14 This evening and into tomorrow morning, comet C/2022 E3 ZTF is located less than 2° east of Aldebaran.

Wednesday

15 Venus and Neptune have a close encounter. As darkness falls, the pair appear 20 arcminutes apart, low above the western horizon. Earlier in the day, at around 12:26 UT in daylight, the pair were just 47 arcseconds apart!

Monday

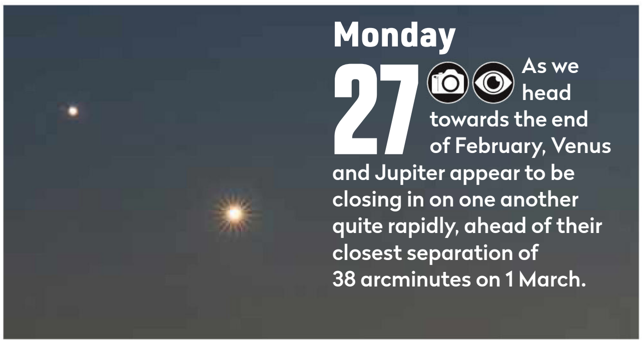
20 The beautiful open cluster M35 reaches its highest position in the sky, due south, around 20:00 UT. The cluster is just visible to the naked eye, and a real treat through binoculars or a small scope.

Wednesday

22 A lovely scene this evening, as the 8%-lit waxing crescent Moon sits midway and slightly below the imaginary line joining Jupiter to Venus low in the west-southwest after sunset.

Sunday

26 This evening's 44%-lit waxing crescent Moon sits 2.7° from the Pleiades open cluster. Catch the pair at their best just after darkness falls.



Monday

27 As we head towards the end of February, Venus and Jupiter appear to be closing in on one another quite rapidly, ahead of their closest separation of 38 arcminutes on 1 March.

Tuesday

28 Mars and the Moon appear close in the morning sky, and continue to get closer as they approach setting at the northwest horizon. An occultation does occur, but sadly after they have both set from the UK.

NEED TO KNOW

The terms and symbols used in The Sky Guide

Universal Time (UT) and British Summer Time (BST)

Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT

RA (Right ascension) and dec. (declination)

These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'

Family friendly Objects marked with this icon are perfect for showing to children

Naked eye Allow 20 minutes for your eyes to become dark-adapted

Photo opp Use a CCD, planetary camera or standard DSLR

Binoculars 10x50 recommended

Small/ medium scope Reflector/SCT under 6 inches, refractor under 4 inches

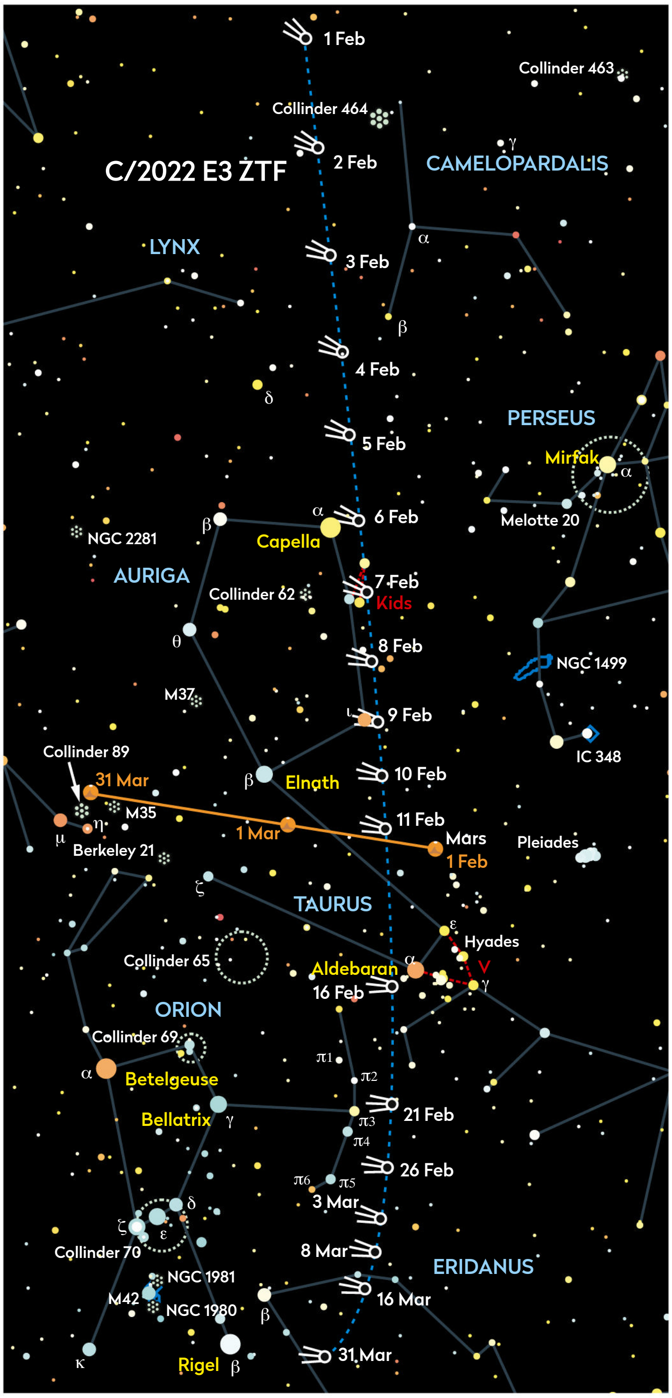
Large scope Reflector/SCT over 6 inches, refractor over 4 inches

GETTING STARTED IN ASTRONOMY

If you're new to astronomy, you'll find two essential reads on our website. Visit **bit.ly/10_easylessons** for our 10-step guide to getting started and **bit.ly/buy_scope** for advice on choosing a scope

DON'T MISS

▶ Comet C/2022 E3 ZTF dims as it rapidly heads south this month



Comet C/2022 E3 ZTF

BEST TIME TO SEE: 8–23 February

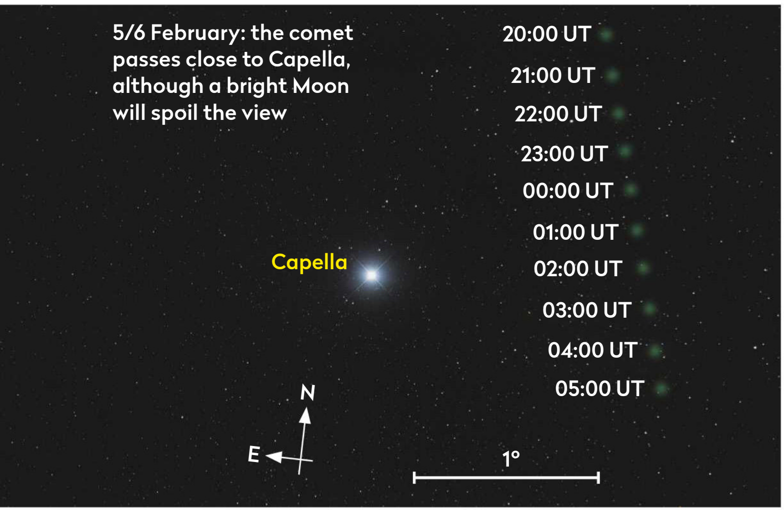
Assuming that it continues to follow predictions, comet C/2022 E3 ZTF will be in naked-eye territory this month, and fairly well-placed for viewing from the UK. On 1 February, the comet is located at high declination in the constellation of Camelopardalis, the Giraffe. Not known for strong patterns, the faint stars of Camelopardalis will make finding the mag. +4.8 comet that little bit harder.

At 00:00 UT on 1 February, the comet is located 2° south of mag. +4.6 HIP 33694, the star that marks the top of the giraffe's head. This star is, in itself, quite tricky to identify. The best we can do is to suggest looking at the point midway between Dubhe (Alpha (α) Ursae Majoris) and Segin (Epsilon (ε) Cassiopeiae). HIP 33694 sits more or less half way between these two brighter and more identifiable stars. At 00:00 UT on 2 February, the comet will have progressed to another 'main' star of Camelopardalis, HIP 29997, with C/2022 E3 lying 1° to the north of this mag. +4.8 star on this date.

As it continues on its south-southwest journey, the comet thankfully passes into a region of more identifiable stars within Auriga, the Charioteer. Unfortunately, as it does so it will be slowly beginning to fade. On the night of 5/6 February, C/2022 E3 ZTF is very conveniently positioned 1° west-northwest to west of Capella (Alpha (α) Aurigae). At 03:00 UT on 6 February, the comet is located 1.5° due west of the star and expected to appear at mag. +5.2.

It passes immediately west of the Kids asterism formed by Eta (η) and Zeta (ζ) Aurigae during the morning of 7 February, and lies two-thirds of a degree to the west of Hassaleh (Iota (ι) Aurigae) on the evening of 8 February. Its subsequent track takes it east of Mars. On the night of 10/11 February it lies northeast of the mag. 0.0 planet, and on 11/12 February it can be found to the southeast. This is the time C/2022 E3 ZTF is expected to have an integrated magnitude of +6.0, theoretically moving into binocular territory, although in truth it was probably here for most of the month anyway.

At 00:00 UT on 15 February, the comet sits 1.5° east of Aldebaran (Alpha (α) Tauri), heading south to track just west of the curved line formed from Pi[1] (π[1]) to Pi[6] (π[6]) Orionis between 18 February through to the start of March. By the time the end of the month has arrived, it is expected to have faded to mag. +8.1.



5/6 February: the comet passes close to Capella, although a bright Moon will spoil the view

ALL PICTURES: PETE LAWRENCE

Venusian encounters

BEST TIME TO SEE: From 15 February, after sunset

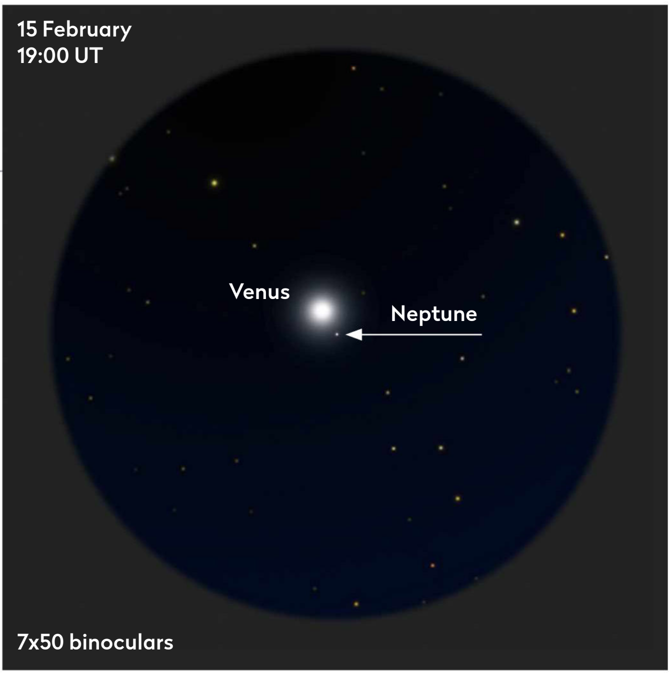
On the evening of 15 February, the brightest and the dimmest planets in the Solar System have an encounter. As darkness falls, mag. –3.8 Venus and mag. +8.0 Neptune will appear just 20 arcminutes apart, low above the western horizon. Close though this appears, earlier in the day, when Neptune sadly wasn't visible from the UK, their closest approach at 12:26 UT had them just 47 arcseconds apart!

A more spectacular planetary conjunction comes later in the month and into early March, when Venus will have moved further to the east for an encounter with bright Jupiter.

The first highlights occur on the evenings of 21, 22 and 23 February, when a slender waxing crescent Moon lies close to both planets. On 21 February, in order from the Sun, you will see first a thin 3%-lit waxing crescent Moon, then Venus followed by Jupiter, setting one after the other. On the evening of 22 February, the Moon will have thickened to 8%-illumination, located slightly below the imaginary 7.5° line connecting both planets. Finally, on 23 February, the now 15%-lit Moon sits east of Jupiter, the gap between the gas giant and Venus having closed slightly to 6.5°.

The gap between worlds continues to close and as darkness falls on 27 February, mag. –3.6 Venus appears 2.5° from mag. –1.9 Jupiter, an impressive sight in its own right. Both planets are around 7° up when astronomical darkness falls, and with a clear western horizon, should appear quite stunning. On the following evening, 28 February, the gap closes to just 1.5°.

The narrowest separation occurs on 1 March, when both planets will appear 39 arcminutes apart at 18:45 UT, and 16° up in a darkening twilight sky. On the evening of 2 March, although the separation will have slightly increased, the pair will still look stunning, sitting just 45 arcminutes apart.



▶ **The brightest planet meets the dimmest mid-month**

Favourable southwest lunar libration

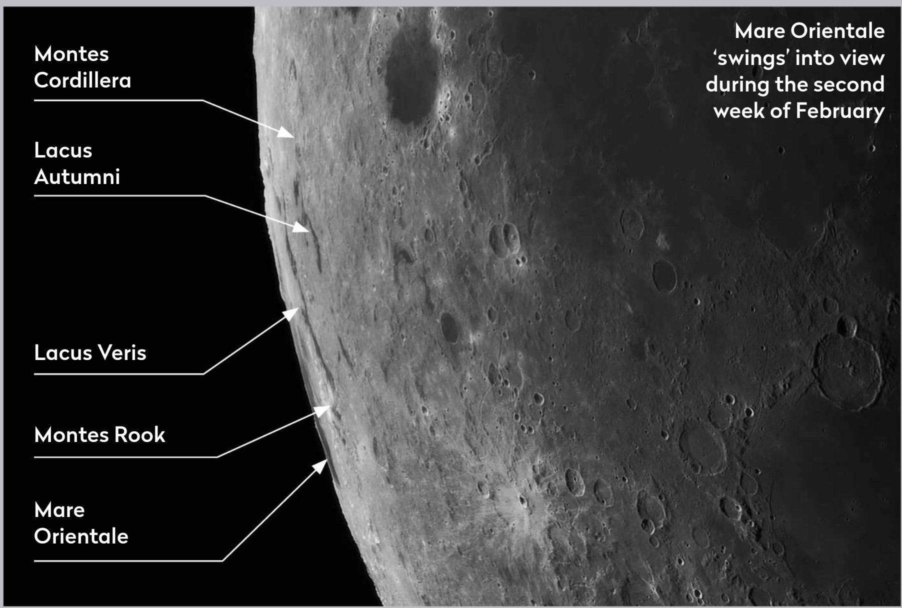
BEST TIME TO SEE: 9–16 February

The Moon points the same face towards Earth due to tidal locking. However, its orbit is an ellipse that causes it to appear to speed up or slow down over a lunar month. In addition, the orbit is tilted to Earth's by around 5°.

Consequently, over a lunar month the Moon appears to rock and roll slightly, a phenomenon known as libration. As this occurs, features on the very edge of the Moon will either be brought into view or rotated out of view.

In the middle of the month, libration favours the southwest limb, bringing a large concentric basin known as Mare Orientale partially into view. Mare Orientale, which ironically means 'Eastern Sea' despite being on the western side of the Moon, would be an impressive feature if viewed from above, resembling a giant bull's eye target on the Moon. Mare Orientale is the dark, central part of the 'target'. Around it are giant concentric mountain ranges and between these are dark lava lakes.

Extreme foreshortening makes it difficult to fully appreciate the complexity of the feature, but with care it is possible to identify the Cordillera and Rook mountain ranges, as well as a number of dark lava lakes sandwiched between them, such as Lacus Autumni and Lacus Veris.



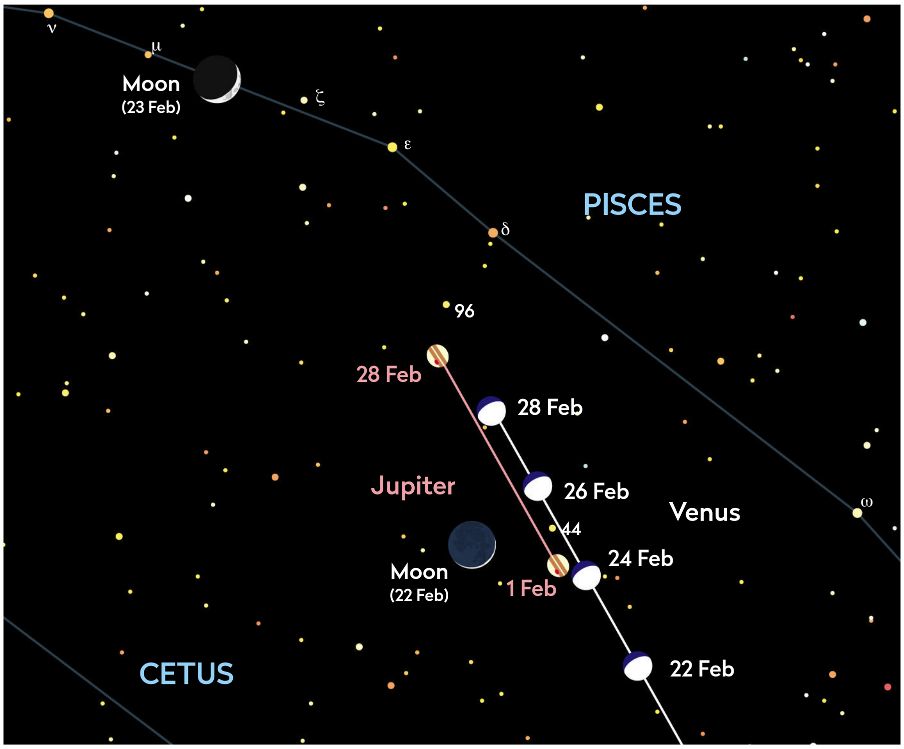
Mare Orientale 'swings' into view during the second week of February

THE PLANETS Our celestial neighbourhood in February

PICK OF THE MONTH

Jupiter

Best time to see: 1 February, from 17:30 UT
Altitude: 34°
Location: Pisces
Direction: South-southwest
Features: Complex atmosphere, Galilean moons
Recommended equipment: 75mm or larger



▲ Jupiter, Venus and a thin Moon will appear close to one another at the end of February

Jupiter is rapidly losing ground to the evening twilight, appearing 29° above the southwest horizon under deep twilight conditions at the start of the month, but reaching only 12° above the western horizon by the time we reach the end of the month.

Through the eyepiece of a telescope, Jupiter's low altitude will mean it will be badly affected by seeing. This causes fine detail to wobble and blur, making such detail difficult to see well. On a more encouraging note, Jupiter's declination is increasing and when next at opposition in early November, it will be able to reach an altitude of 50° in a dark sky.

A small telescope will currently show the planet's disc, two main belts and, for apertures above 100mm, the persistent atmospheric feature known as the Great Red Spot. The four Galilean moons are another amazing sight to watch as their starlike dots appear to dance endlessly around the planet.

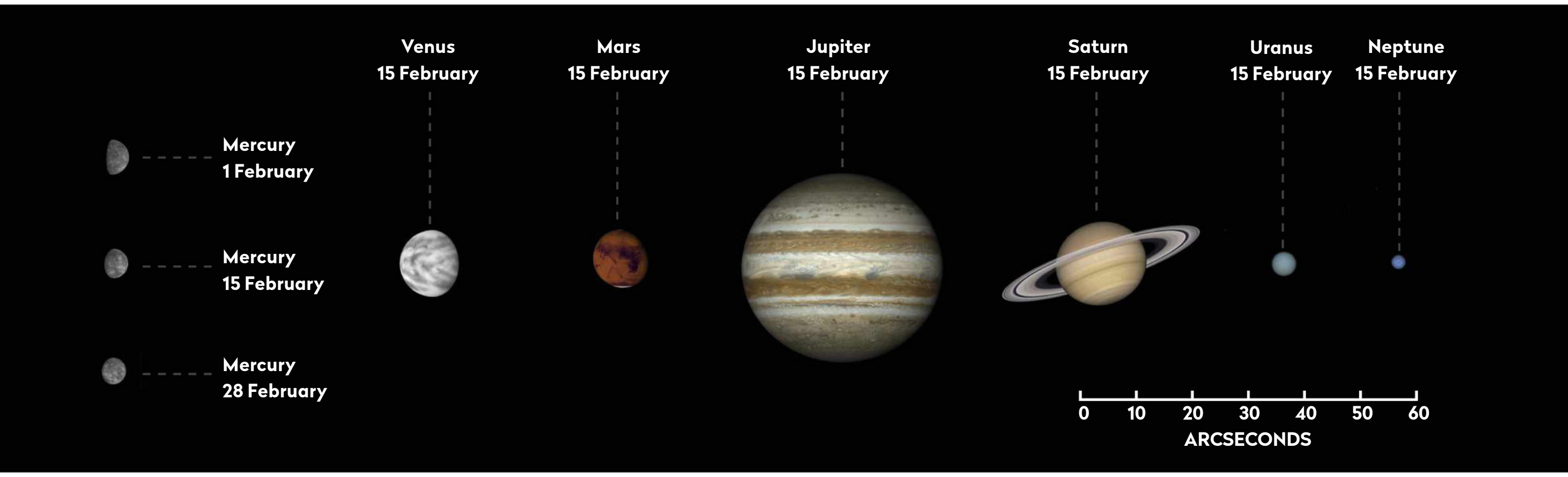
As the end of February approaches and we move into the start of March, mag. –1.9 Jupiter will appear really close to mag. –3.9 Venus, the two planets forming an impressive pair above the western horizon even despite their low altitude. On 28 February, they will appear 1.5° apart, a prelude to their closest separation of just 0.6° on 1 March. If you have several clear evenings, watching a planetary conjunction involving two bright planets is fascinating. The rapid positional shifts really give you a sense of the three-dimensional nature of our Solar System.

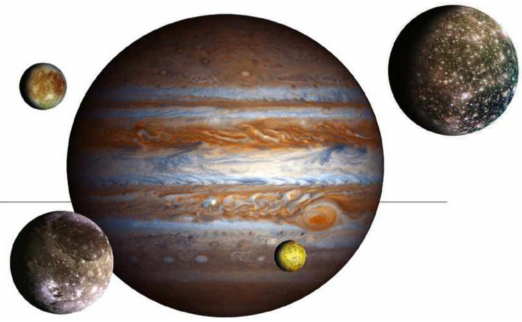
On the evening of 22 February, a thin 8%-lit waxing crescent Moon sits south of the imaginary line joining Venus to Jupiter, a particularly striking display and a great scene to photograph if the conditions are clear.

PETE LAWRENCE X 2

The planets in February

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope





Mercury

Best time to see: 1 February, 40 minutes before sunrise
Altitude: 3.3° (very low)
Location: Sagittarius
Direction: Southeast

Having reached greatest western elongation on 30 January, Mercury is a low morning object this month. Its altitude before sunrise is dropping and despite being around mag. 0.0 for the first half of February, brightening to –0.5 by the end of the month, Mercury is unlikely to be seen.

Venus

Best time to see: 28 February, 1 hour after sunset
Altitude: 16°
Location: Pisces
Direction: West-southwest

Evening object setting two hours and 15 minutes after sunset at the start of February. Shining at mag. –3.8 on 1 February, if the sky is clear after sunset, it'll be hard to miss. Very close to Neptune on the evenings of 14 and 15 February. From the UK, the separation on 14 February is 50.2 arcminutes, reducing to 21.8 arcminutes on the 15th. On the evening of 22 February, mag. –3.9 Venus sits 7.5° from mag. –2.0 Jupiter, a slender 8%-lit waxing crescent Moon also joining the party. By the end of the month, its separation from Jupiter reduces to 1.5°.

Mars

Best time to see: 1 February, 20:00 UT
Altitude: 62°
Location: Taurus
Direction: South

Mars is moving away from Earth and consequently is dimming and shrinking through the eyepiece. On 1 February, mag. –0.2 Mars appears 10 arcseconds across. By 28 February, its magnitude drops to +0.4 and its apparent diameter to 8 arcseconds. It remains in Taurus all month.

Saturn

Not visible this month

Saturn is in conjunction with the Sun on 16 February and is not visible this month.

Uranus

Best time to see: 1 February, from 17:30 UT
Altitude: 52°
Location: Aries
Direction: Just west of south

An evening planet, no longer visible at its highest position under astronomically dark skies. On 1 February, true darkness sees Uranus at an altitude of 52°, only a fraction below its best, but by the end of the month, its altitude will have dropped to 38° before this condition is met. Uranus shines around mag. +5.8 and requires binoculars to see convincingly. The southern limb of the Moon is around 4 arcminutes from Uranus under daylight conditions at 11:45 UT on 25 February.

Neptune

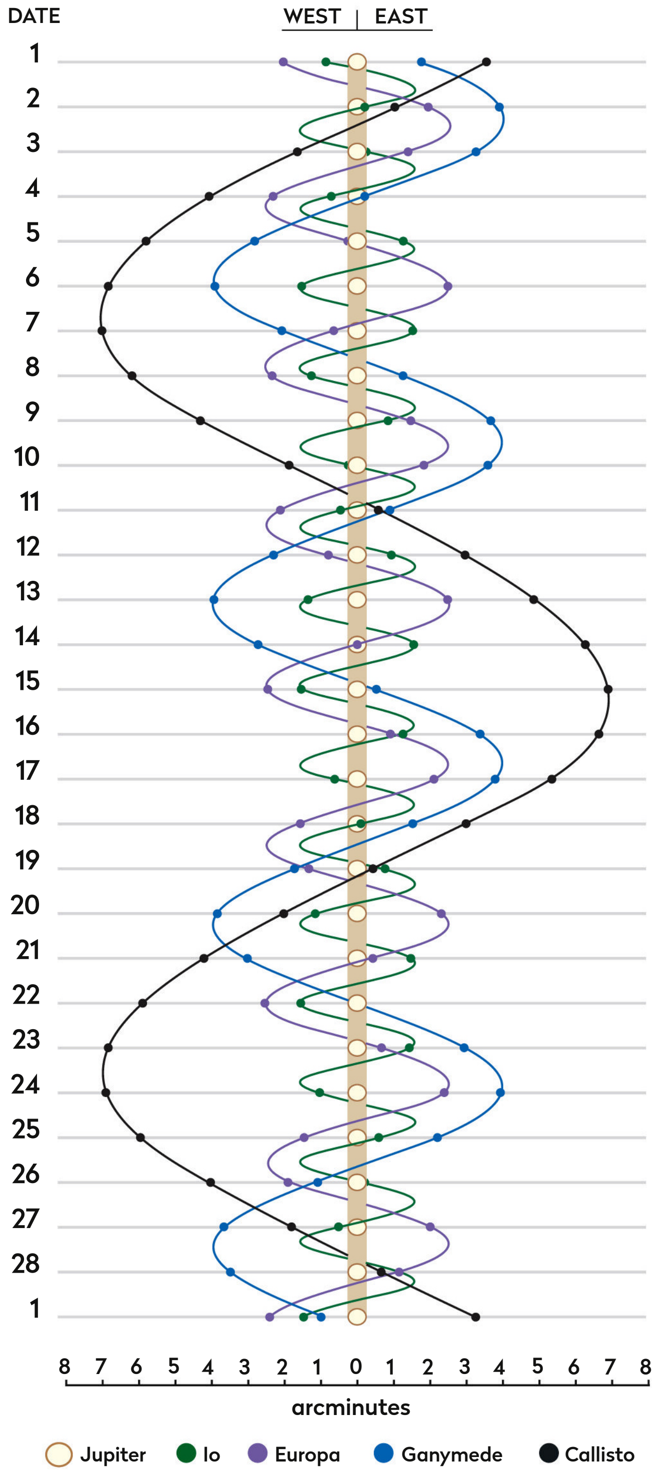
Best time to see: 1 February, from 18:50 UT
Altitude: 16°
Location: Aquarius
Direction: West-southwest

The observing window closes on Neptune this month, the dim planet being just 16° up as true darkness falls at the start of February, but unable to be seen against dark skies from 22 February onwards. As Venus rushes towards its close encounter with Jupiter at the end of the month, it will also make a harder-to-see close pass of Neptune, visible on the evenings of 14 and 15 February.

MORE **ONLINE**
Print out observing forms for recording planetary events

JUPITER'S MOONS: FEBRUARY

Using a small scope you can spot Jupiter's biggest moons. Their positions change dramatically over the month, as shown on the diagram. The line by each date represents 00:00 UT.



THE NIGHT SKY – FEBRUARY

Explore the celestial sphere with our Northern Hemisphere all-sky chart

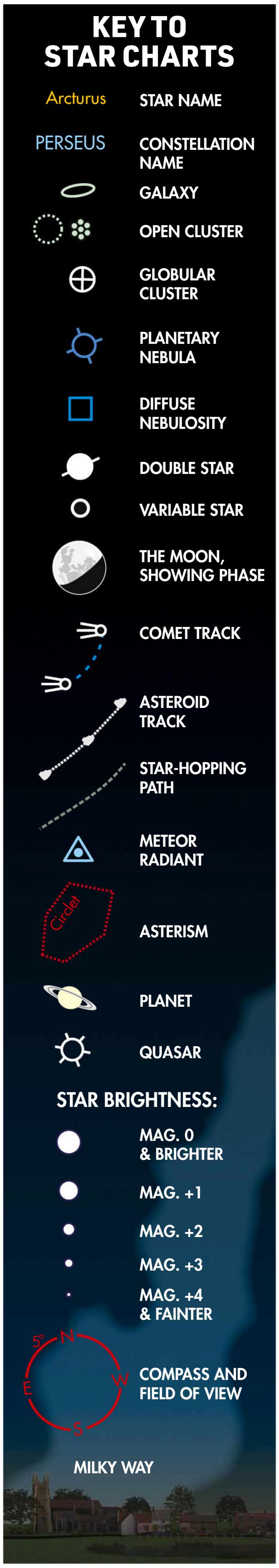


CHART: PETE LAWRENCE

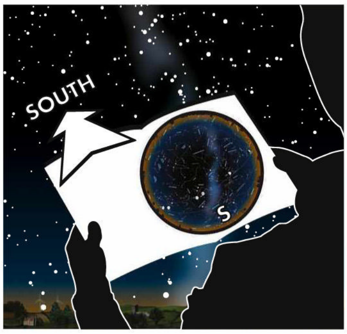
When to use this chart

1 February at 00:00 UT
15 February at 23:00 UT
28 February at 22:00 UT

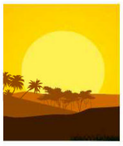
On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

How to use this chart

1. Hold the chart so the direction you're facing is at the bottom.
2. The lower half of the chart shows the sky ahead of you.
3. The centre of the chart is the point directly over your head.



Sunrise/sunset in February*



Date	Sunrise	Sunset
1 Feb 2023	07:56 UT	16:52 UT
11 Feb 2023	07:37 UT	17:12 UT
21 Feb 2023	07:16 UT	17:32 UT
3 Mar 2023	06:54 UT	17:51 UT

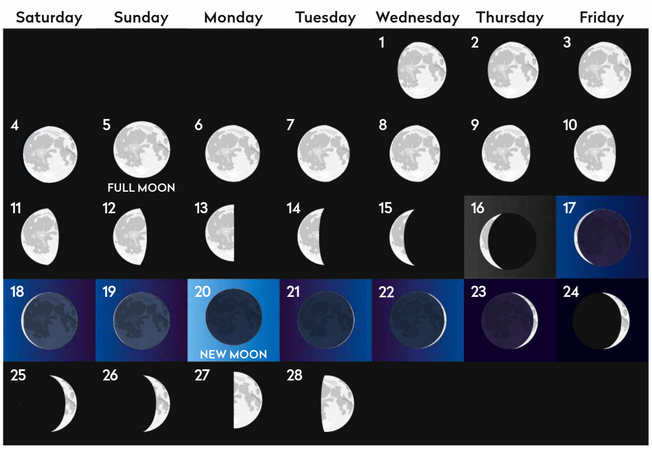
Moonrise in February*

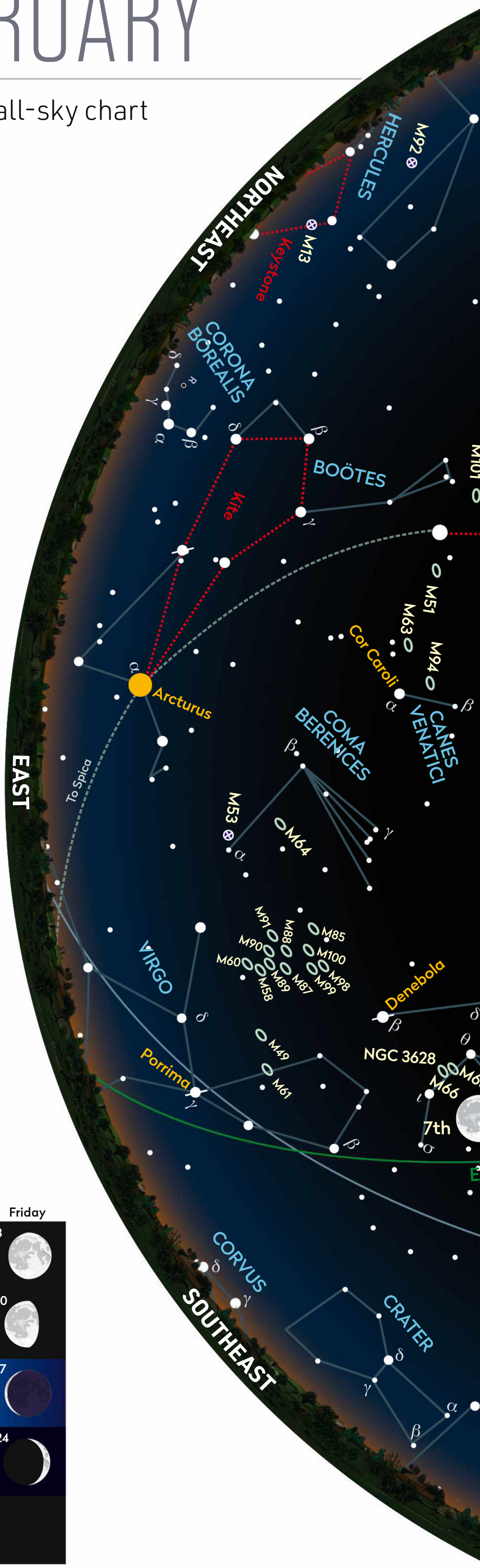
Moonrise times

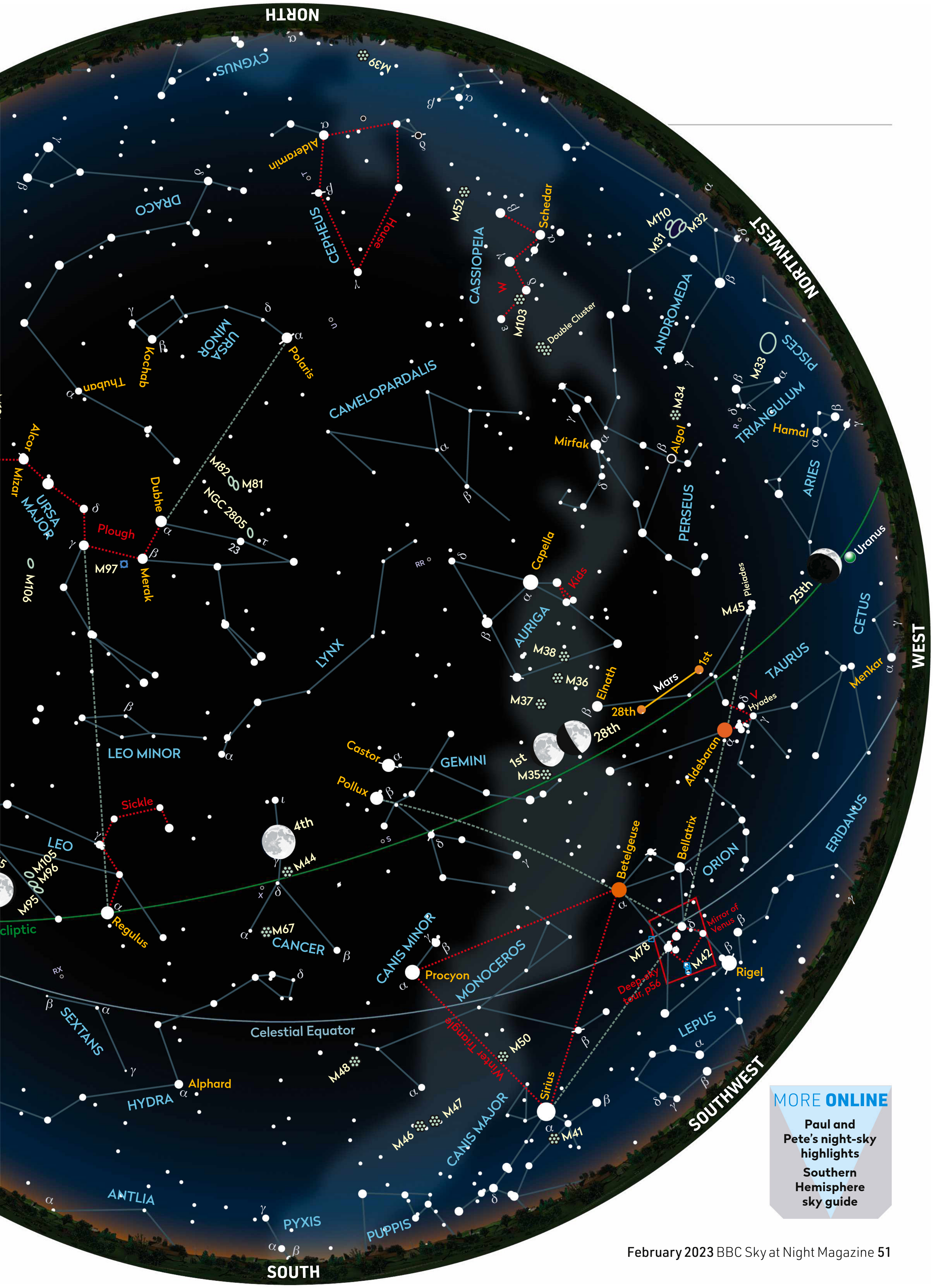
1 Feb 2023, 12:13 UT	17 Feb 2023, 06:29 UT
5 Feb 2023, 16:23 UT	21 Feb 2023, 08:13 UT
9 Feb 2023, 21:20 UT	25 Feb 2023, 09:00 UT
13 Feb 2023, 01:16 UT	1 Mar 2023, 10:53 UT

*Times correct for the centre of the UK

Lunar phases in February



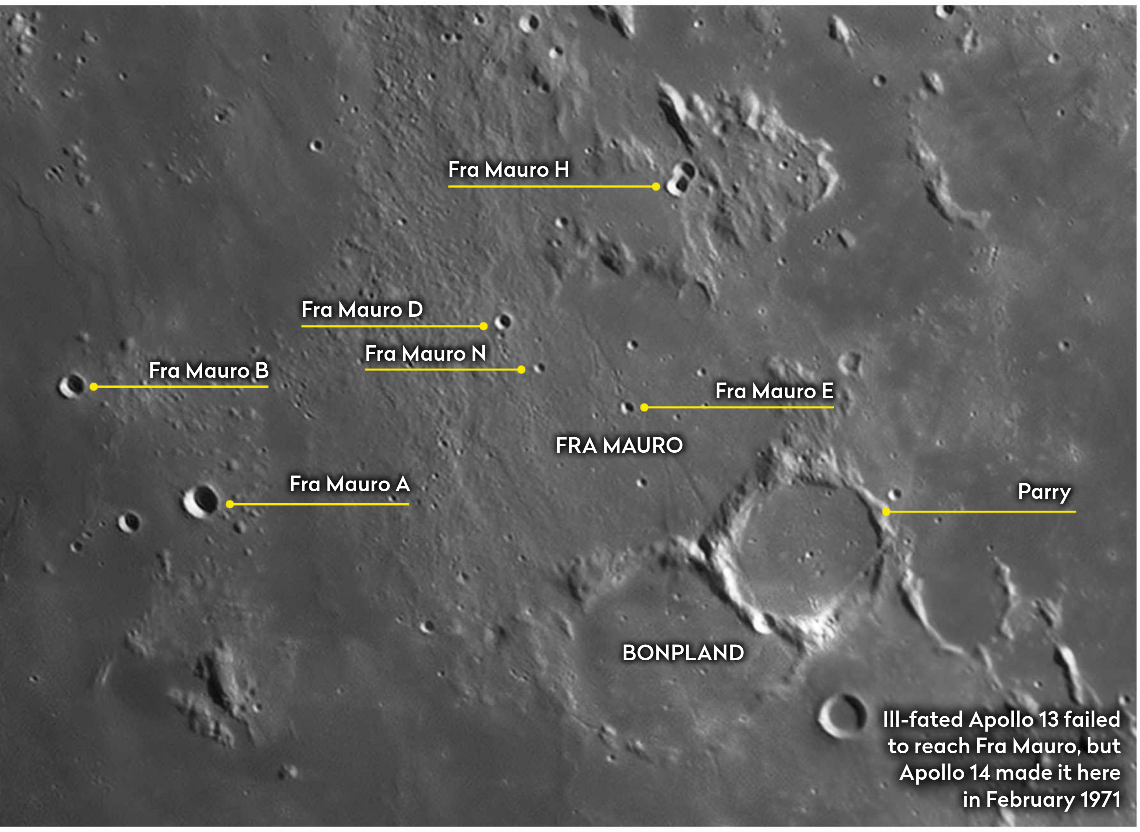




MORE ONLINE

Paul and Pete's night-sky highlights

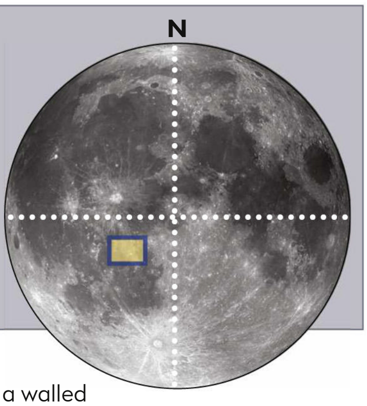
Southern Hemisphere sky guide



Ill-fated Apollo 13 failed to reach Fra Mauro, but Apollo 14 made it here in February 1971

Fra Mauro

Type: Crater
Size: 96km
Longitude/Latitude: 17° W, 6.1° S
Age: Older than 3.9 billion years
Best time to see: One day after first quarter (1 March) or last quarter (13–14 February)
Minimum equipment: 50mm refractor



Fra Mauro is a quintessential example of a walled plain. Measuring 96km in diameter and 800m in depth, its ancient form can be located east of 300km **Mare Cognitum**, 'the sea that has become known'. It is not the clearest of lunar craters, its ringed plain defined by a gently raised rim to the west, appearing broken in form to the east. It forms a characteristic trio with 60km **Bonpland** and 48km **Parry** to the south. This pair are ancient too, but presumably younger than Fra Mauro as their rims appear to bulge into Fra Mauro's boundary, inverting the curve of the walled plain's rim. This suggests they were formed after Fra Mauro and overlay its edge.

Fra Mauro's rim is rough and elevated to the southeast where it joins onto the rim of Parry. The co-joined interlopers then take the reins, their northern rims giving form to Fra Mauro's southern edge. As mentioned, the western rim section of Fra Mauro is gentle, more a subtle ridge formed from an expanse of gently rising and falling highland material. As it heads north, Fra Mauro's rim appears to elongate northward, almost as if there is yet another ancient form extending the walled plain in this direction. Inside the rim border lies 5km **Fra Mauro D**.

Large-aperture high-resolution imaging setups may like to try an interesting challenge here. A line of craterlets of ever-decreasing size gently curve south and southeast towards 3km **Fra Mauro N**. The four craterlets (north to south) are 1.9km, 1.5km, 1.3km and 1.3km. If you want a really tough challenge, there is another 0.7km craterlet that continues the progression, but this would require an aperture over 350mm and extremely good seeing to record. The region to the northeast is picked out by rough, elevated terrain. A pair of similar-sized craters sit in the middle of the region, the southernmost one labelled as 6km **Fra Mauro H**.

Internally, Fra Mauro's floor is relatively flat with no indication of a central mountain complex. The half to the west appears rougher than that to the east. A number of craterlets pockmark the region, the largest being in the centre of the walled plain; 4km **Fra Mauro E**. A north–south rille runs down the centre of Fra Mauro, best seen when the terminator is nearby and the Sun's light oblique. The rille appears as a graben, a region of the surface which has dropped between two fault lines. It splits in two just to the south of Fra Mauro E, one portion running close to the western rim of Parry, the other entering Bonpland where it becomes even more complex, heading west and south. The craters **Fra Mauro A and B**, located further to the west are banded, exhibiting dark radial bands on their inner rim walls.

Fra Mauro is a famous feature on the Moon's surface. Named after a Venetian cartographer, it was the intended landing site for Apollo 13, the mission which had to be aborted when an onboard oxygen tank exploded.

Fra Mauro crater is a quintessential example of a walled plain

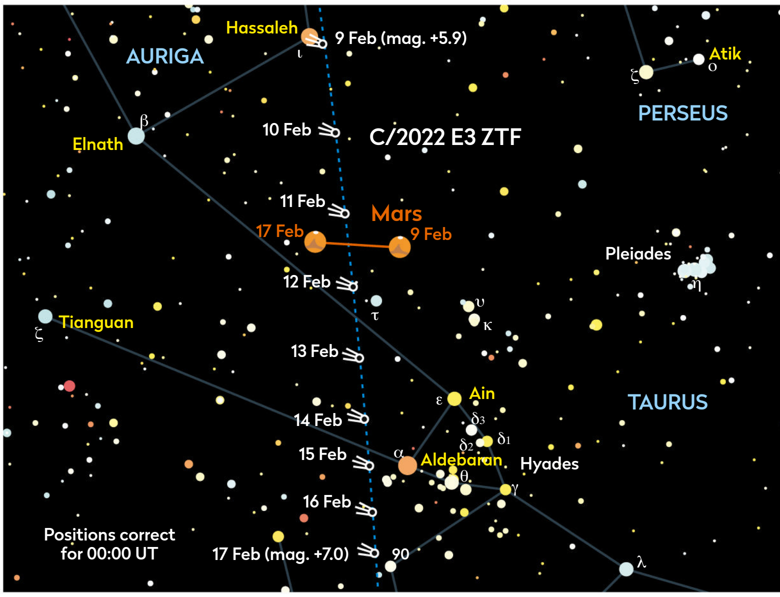
PETE LAWRENCE X 3

COMETS AND ASTEROIDS

Fingers crossed for comet C/2022 E3 ZTF reaching naked-eye visibility this month

Comet C/2022 E3 ZTF is well-positioned at the start of February, high in the sky and theoretically above the threshold for naked-eye visibility. There are a couple of reasons why this is unlikely to be the case though. First, the comet is expected to reach a peak magnitude of +4.8 around the end of January and start of February. Comet magnitudes can be misleading because they refer to how bright the object would look if its light were condensed into a single point like a star. If the comet has a tangible size, that light is spread out, making its surface dimmer than its rating would suggest. Secondly, there will be a bright Moon and this will sadly diminish the appearance of C/2022 E3 ZTF. You can find where the comet will be throughout February on page 46, and as it passes some easy-to-find sky markers, there is a good chance to catch it using binoculars or a small telescope.

C/2022 E3 ZTF was discovered by the Zwicky Transient Facility (ZTF) on 2 March 2022. The ZTF is a widefield survey setup using an infrared- and visible-light-sensitive camera attached to the 1.22m Samuel Oschin Telescope at the Palomar Observatory in California. The object was originally thought to be an asteroid shining at mag. +17.3 when discovered, at a distance 4.3 times further from the Sun than Earth. It's a long-period comet with an orbit that takes around 50,000 years to complete. At the farthest point in its orbit it lies 2,800 AU from the Sun; at its closest it is 1.11 AU, which last occurred on 12 January. The orbital positions of Earth and the comet mean that C/2022 E3 ZTF will be closest to our planet on 2 February, separated from us by a mere 43 million kilometres (0.29 AU).



▲ **From 11 February, moonlight abates as the comet nears Mars**

STAR OF THE MONTH

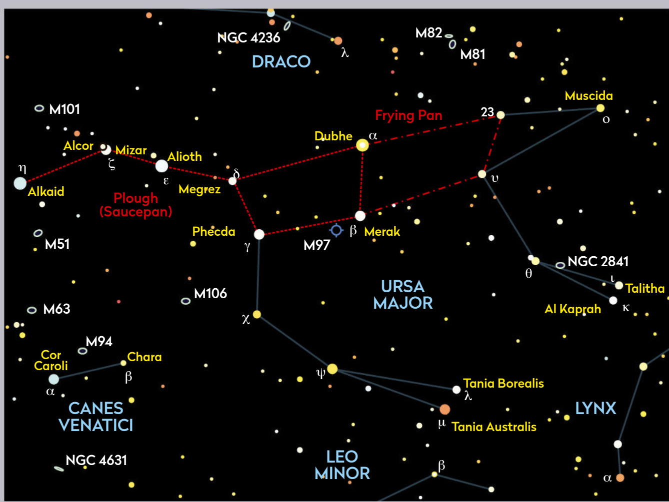
Muscida, the nose of the Great Bear, Ursa Major

Whether or not you like the idea of the Plough asterism being referred to as 'the Saucepan', the name works well in modern times – so well that the Saucepan can be extended to become the Frying Pan by incorporating 23 and Upsilon (υ) Ursae Majoris into the arrangement. Keep going and eventually you'll arrive at Muscida (Omicron (ο) Ursae Majoris), the star that represents the nose of the Great Bear. The name Muscida comes directly from the Latin for 'muzzle'.

Muscida has a spectral classification of G4 II-III; a yellow (G4) star between the bright-giant (II) and normal-giant (III) stages of stellar evolution. It lies at a distance of 182 lightyears and is 138 times more luminous than our Sun. It is estimated to be 15 times larger than the Sun and like our own star rotates quite slowly: 3km/s compared to the Sun's 2km/s.

It has a shared proper-motion companion, a dim 15th-magnitude M1 red dwarf star which lies at a distance of 400 AU from the primary. From Earth, the separation is 7.1 arcseconds. It's not known whether the pair are orbitally linked. If they are, the orbital period would be at least 4,100 years – too long to accurately determine at present.

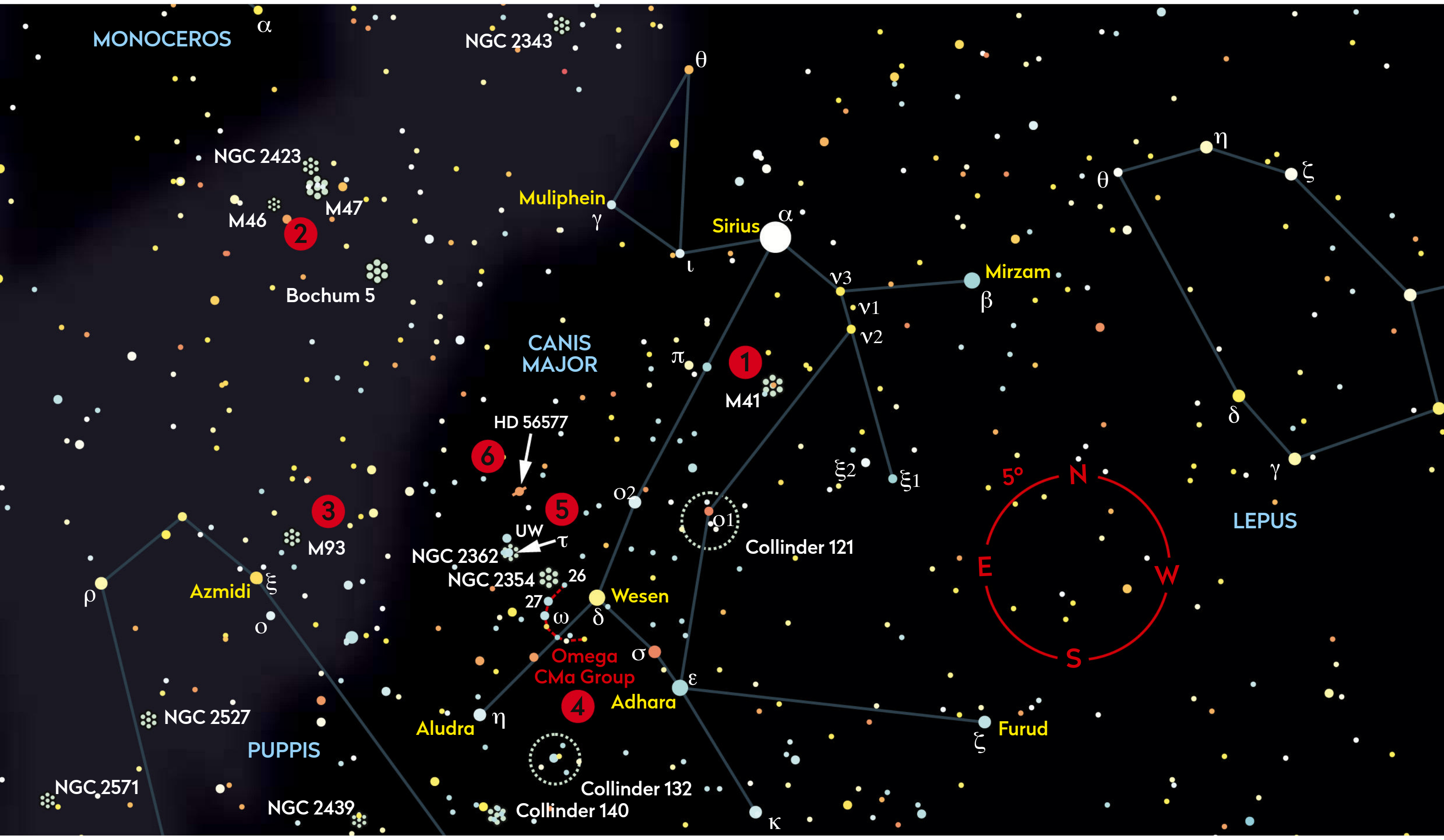
▼ **Muscida, from the Latin word for 'muzzle', is found at the bear's snout**



An extrasolar planet was detected in orbit around Muscida in 2012. Designated Omicron Ursae Majoris b, this is a gas giant 4.1 times larger than Jupiter, which takes 1,630 days to orbit the star at a distance of 3.9 AU.

BINOCULAR TOUR With Steve Tonkin

This month we're off to a dog show, finding the best in class in Canis Major



1. M41

10x50 This open cluster is bright enough for you to see it with your naked eye in a transparent sky. It is 4° south of mag. –1.1 Sirius (Alpha (α) Canis Majoris) and is large enough to be an obvious cluster of stars in 10x50 binoculars. Using averted vision at a dark site, you should be able to resolve up to 10 of the brighter stars against the background glow of fainter members. ☐ **SEEN IT**

2. M46/47

10x50 M46 and M47 offer contrasting examples of how open clusters can appear in small binoculars; you will find them 5° south of mag. +3.9 Alpha (α) Monocerotis. The 1,600-lightyear-distant M47 is large and loose, but although M46 appears to be a similar size, it is actually much larger, richer and more compact. It is more than three times as distant at 5,500 lightyears and you probably won't be able to resolve any of its stars at all. ☐ **SEEN IT**

3. M93

15x70 If you place mag. +3.3 Azmidi (Xi (ξ) Puppis) at the southeast of the field of view, M93 should appear near the centre of the field. M93 is a bright, rich, wedge-shaped cluster in which some 25–30 stars are visible in 15x70 binoculars, against a glowing backdrop of fainter stars. M93 is unusual in that, unlike most open clusters which are sparser at the periphery, it is the centre of this cluster that is sparse. ☐ **SEEN IT**

4. The Omega CMa Group

10x50 Mag. +4.0 Omega (ω) Canis Majoris lies 1.5° east of mag. +1.8 Wezen (Beta (β) Canis Majoris). Note that it is a brilliant white compared to the fainter yellowish star just to the south. These two are part of a very pretty C-shaped string of stars of varying colour that extends from mag. +5.9 26 CMa in the north, through mag. +4.4 27 and Omega CMa, to a mag. +5.5 yellow star 1° south of Wezen. ☐ **SEEN IT**

5. UW Canis Majoris

10x50 Look 2.7° northeast of Wezen for a pair of dazzlingly blue stars. The brighter one is mag. +4.4 Tau (τ) Canis Majoris, but more interesting is the fainter mag. +4.8 UW Canis Majoris, less than 0.5° north of Tau CMa. UW is a blue supergiant whose brightness falls by half a magnitude every 4.39 days as it is eclipsed by a fainter companion. ☐ **SEEN IT**

6. The 'Winter Albireo'

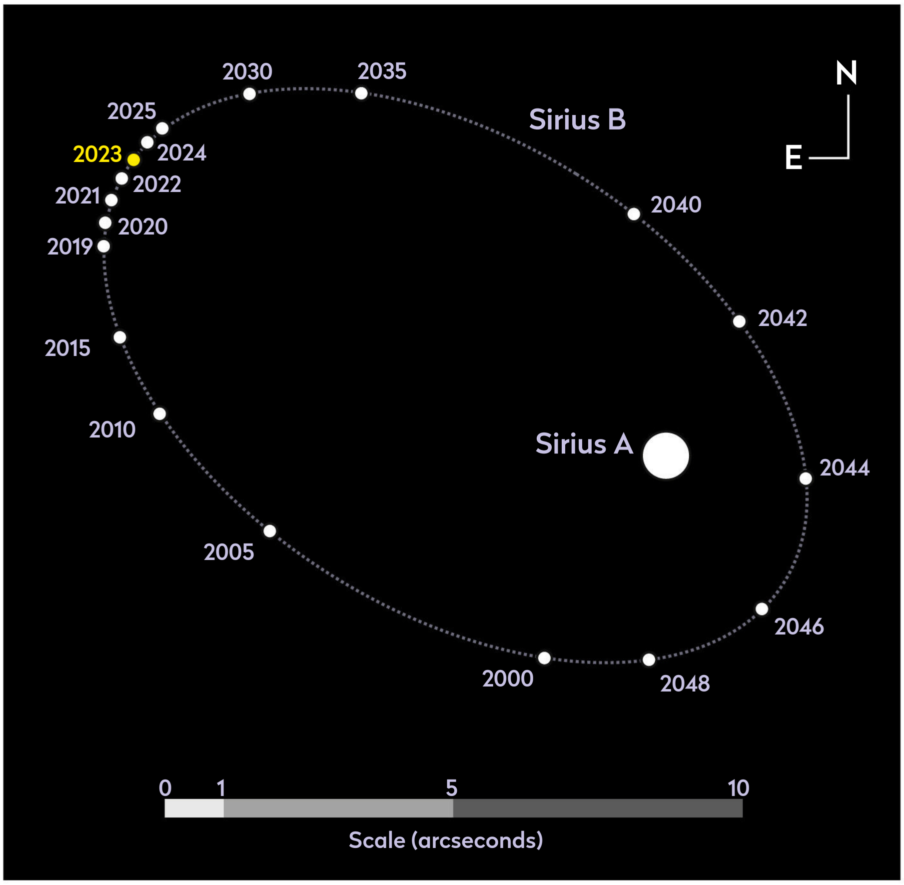
15x70 Did you know that there is a winter equivalent of one of summer's popular double-star showpieces? The 'Winter Albireo' is HD 56577, 1.7° north of Tau CMa. With a separation of 27 arcseconds, it is a bit tighter than its summer cousin, so use 15x70s to separate the mag. +4.8 orange and mag. +5.8 white components, contrasting beautifully with the blue of UW CMa in the same field of view. ☐ **SEEN IT**

☑ Tick the box when you've seen each one

PETE LAWRENCE X 3

THE SKY GUIDE CHALLENGE

Can you beat Sirius's glare to identify its faint companion the Pup Star?



▲ **Sirius B is currently as far away as it gets from Sirius A – the ideal time to catch a glimpse**

Sirius is the brightest nighttime star, shining at mag. –1.5, a beacon in the UK's winter sky. Its brightness makes it easy to find, but if you need assistance, simply follow the line of Orion's Belt down and left (southeast), a direction that points directly to Sirius. At 8.6 lightyears distance, Sirius is one of the Sun's nearest neighbours. It has a white dwarf companion and this month's challenge is to try to see or image this.

There are issues. Sirius never gets high above the UK horizon when due south and this tends to keep it in a more turbulent and unstable part of the sky. You can see the effects of this on a cold, crisp winter night, when the star flickers and flashes distinct colours. Atmospheric seeing causes the flickering; the colours appear through atmospheric dispersion. Together they produce a very striking effect.

Through a telescope's eyepiece, Sirius's brightness combined with atmospheric instability cause the star's light to spread, flicker and generally be a nuisance when looking for its fainter companion. The primary is known as Sirius A, the white dwarf secondary Sirius B. Being the brightest star in Canis Major, the Great Dog, Sirius A is also known as the 'Dog Star', so predictably the companion has become known as the 'Pup'.

The Pup shines at mag. +8.4 and the pair of stars have a mutual orbit that takes 50.1 years to complete. Consequently, the apparent distance between Sirius A and B varies over the years. At present they are close to maximum separation, making this an ideal time to try to record a view of the Pup.

The separation varies from less than 3 arcseconds to around 11 arcseconds. It is currently around 11 arcseconds – about the same as the current apparent diameter of Venus. Take a telescope look at Venus in the evening sky and record which eyepiece you need to use to get a distinct disc. Commit this apparent disc size to memory. If you plan to image the Pup, you'll also need a setup that can render Venus as a tangible disc. It's important to recognise how small the separation is as there have been many false claims of capturing the Pup over the years, based on seeing a field star way beyond the separations mentioned here.

For a visual observation, fitting a straight edge – for example, aluminium foil – to the focal plane of an eyepiece allows you to block the primary's light. Just be sure you know which direction you need to keep visible! Alternatively, viewing Sirius under darkening twilight brings the contrast down and may make the Pup easier to see.

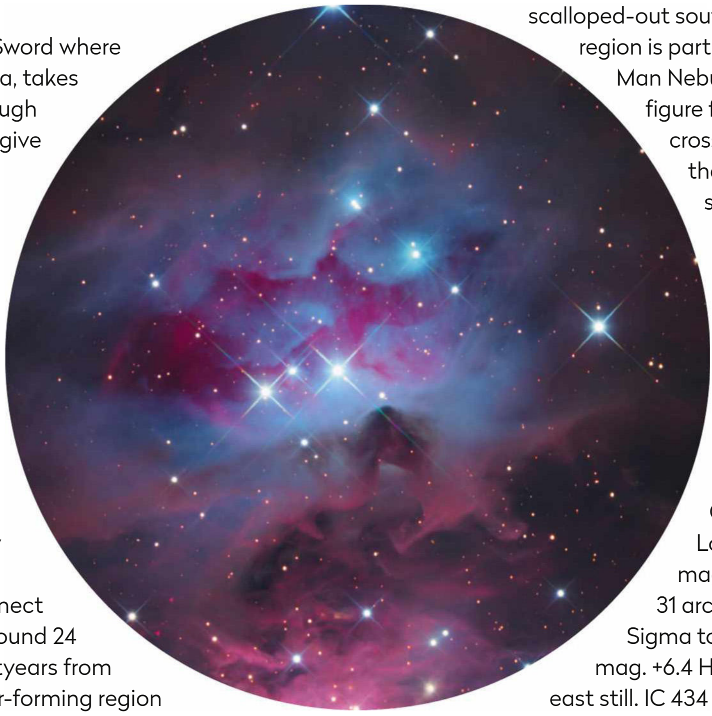
A strip of foil taped to the focal plane of your Pup-hunter eyepiece will help block the dazzle of Sirius A

DEEP-SKY TOUR

We have our head in the clouds as we look for nebulosity in Orion's Belt and Sword

1 M42

We'll start in Orion's Sword where M42, the Orion Nebula, takes pride of place. Magnificent through any instrument, smaller scopes give a lovely overview of this fourth-magnitude nebula, easily revealing the bright kidney-shaped 'core' within which the tightly packed stars of the Trapezium Cluster are embedded. The swept-back 'arms', the Sail and (confusingly) the Sword, are obvious, giving M42 its distinctive shape. Larger scopes let you explore tendrils of excited hydrogen. Under very dark skies it may be possible to see the swept-back arms reconnect to form a loop. The nebula is around 24 lightyears across and 1,340 lightyears from the Sun. It's also the closest star-forming region visible from Earth. ☐ **SEEN IT**



▲ **It's easy to see how the Running Man Nebula got its name – dark lanes cross glowing NGC 1977 to form a ghostly runner in the clouds**

WALTER PRIMIK/CCDGUIDE.COM, CHART BY PETE LAWRENCE

2 M43

Eight arcminutes north and slightly east of the Trapezium sits the comma-shaped emission nebula known as M43 or De Mairan's Nebula. Smaller instruments show a smooth nebulous region with seventh-magnitude variable NU Orionis slightly offset from the centre. NU (not to be confused with Nu (ν) Orionis) powers the nebula, causing it to glow. The distinctive comma shape doesn't become apparent until you go above 250mm of aperture. M43 appears separated from M42 by a dark dust lane, itself extending towards the Trapezium to form a dark feature known as the 'Fish's Mouth'. M43 is 1,300 lightyears distant and around 2.1 lightyears across. ☐ **SEEN IT**

3 NGC 1977

Head 26 arcminutes north from NU Orionis in M43 to arrive at a distinctive group of three stars: mag. +4.6 42, mag. +7.3 V359 and mag. +5.2 45 Orionis. The trio are surrounded by the east–west band of reflection nebulosity, NGC 1977. The brightest part of this 40 x 25-arcminute nebula sits south of the three stars. A darker area south of the western part of the nebula creates a distinctive scalloped-out southern boundary. The whole region is part of Sh2-279, named the Running Man Nebula because of the silhouetted figure formed from darker lanes crossing NGC 1977 and in between the brighter nebula and two smaller nebulae to the north: NGC 1973 and NGC 1975. The Running Man is best 'seen' through long-exposure photography. ☐ **SEEN IT**

4 IC 434

Next is emission nebula IC 434. Head north to mag. +1.7 Alnitak (Zeta (ζ) Orionis), the eastern Belt star. Look 50 arcminutes southwest to mag. +3.8 Sigma (σ) Orionis. Head 31 arcminutes east-southeast of Sigma to mag. +6.2 HIP 26713, then mag. +6.4 HIP 26820 16 arcminutes further east still. IC 434 appears as a linear curtain of nebulosity, its brighter and straighter edge running from Alnitak to a point between HIP 26713 and 26820. It is hard to see so dark skies, an aperture over 250mm, and a hydrogen-beta filter are recommended. Identify mag. +7.5 HIP 26756 using our chart and try to see the small dark notch interrupting IC 434's curtain. If you see this, well done – you've found the Horsehead Nebula! ☐ **SEEN IT**

5 NGC 2023

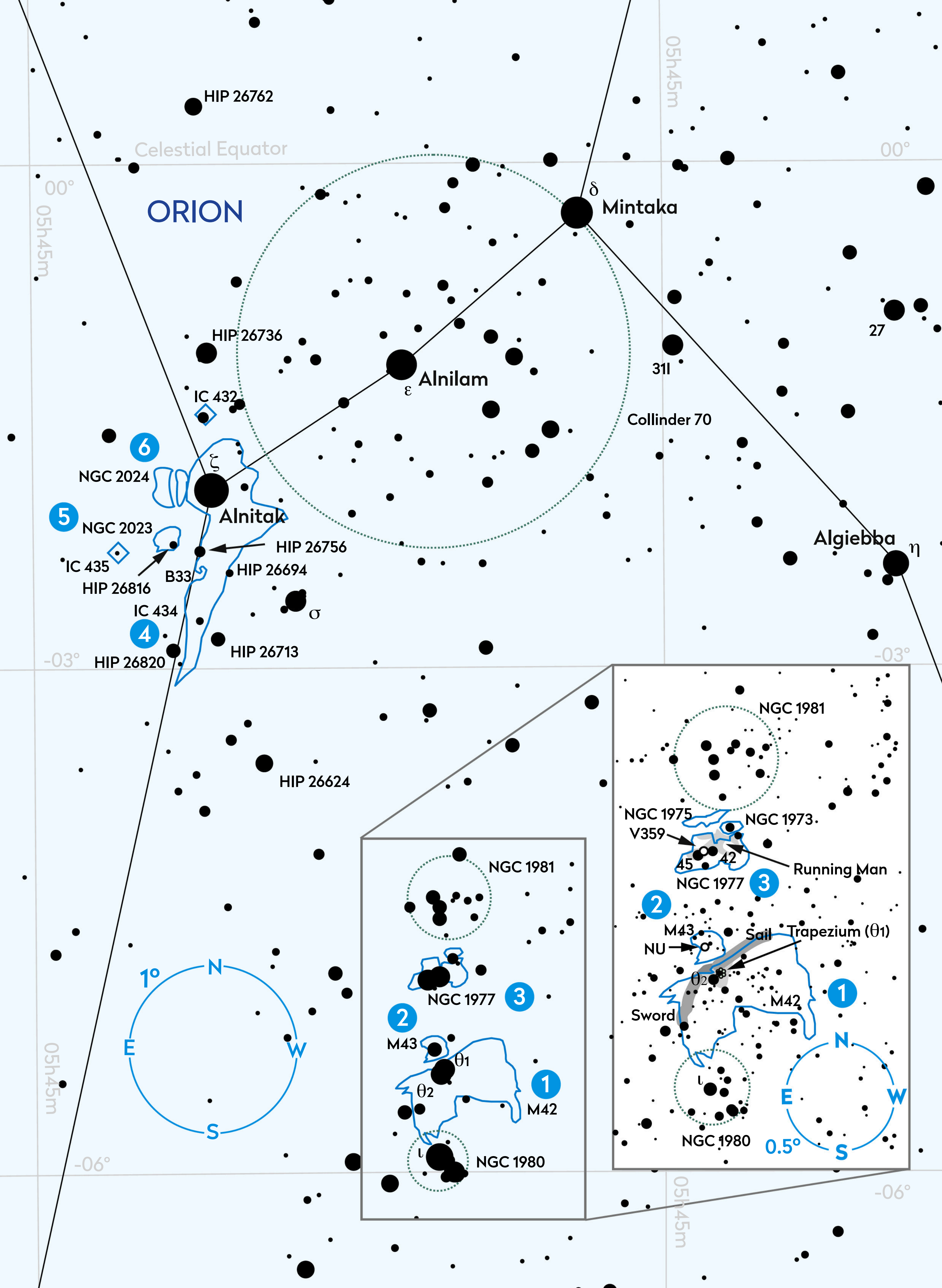
The Horsehead can be tough even with a large telescope. Thankfully, our next target is easier. Look 10 arcminutes east-northeast of HIP 26756 (see target 4) to locate mag. +7.8 HIP 26716. You're now looking at the heart of NGC 2023. The nebulosity may not be obvious at first as it looks like a smooth, misty glow around HIP 26716. A small scope shows this well. Looking carefully it should be possible to see that it extends further east than west. A large telescope shows details, with darker patches breaking the nebula's smoothness. ☐ **SEEN IT**

6 NGC 2024

Our final target is simple to locate and relatively bright at mag. +10.0, but if this sounds like an easy end to the tour, think again. NGC 2024 sits 15 arcminutes east-northeast of Alnitak, whose light makes the nebula hard to see. A 150mm scope reveals a large 11-arcminute patch crossed by a 3-arcminute-wide dark lane running southeast to north, curving northeast at the last minute. Larger instruments should hint at more dark tendrils emanating from the central lane like a candle flame. This is NGC 2024, the Flame Nebula. ☐ **SEEN IT**

This Deep-Sky Tour has been automated
ASCOM-enabled Go-To mounts can now take you to this month's targets at the touch of a button, with our Deep-Sky Tour file for the EQTOUR app. Find it online.

More **ONLINE**
Print out this chart and take an automated Go-To tour. **See page 5 for instructions**



ORION
Celestial Equator
HIP 26762
HIP 26736
IC 432
Mintaka
δ
Alnilam
ε
311
27
Collinder 70
6
NGC 2024
ζ
Alnitak
5
NGC 2023
HIP 26756
IC 435
HIP 26816
B33
HIP 26694
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IC 434
4
HIP 26820
HIP 26713
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NGC 1981
NGC 1977
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2
M43
θ1
θ2
1
M42
ι
NGC 1980
NGC 1975
NGC 1973
V359
45
42
Running Man
Sail
Trapezium (θ1)
NU
Sword
0.5°

AT A GLANCE How the Sky Guide events will appear in February

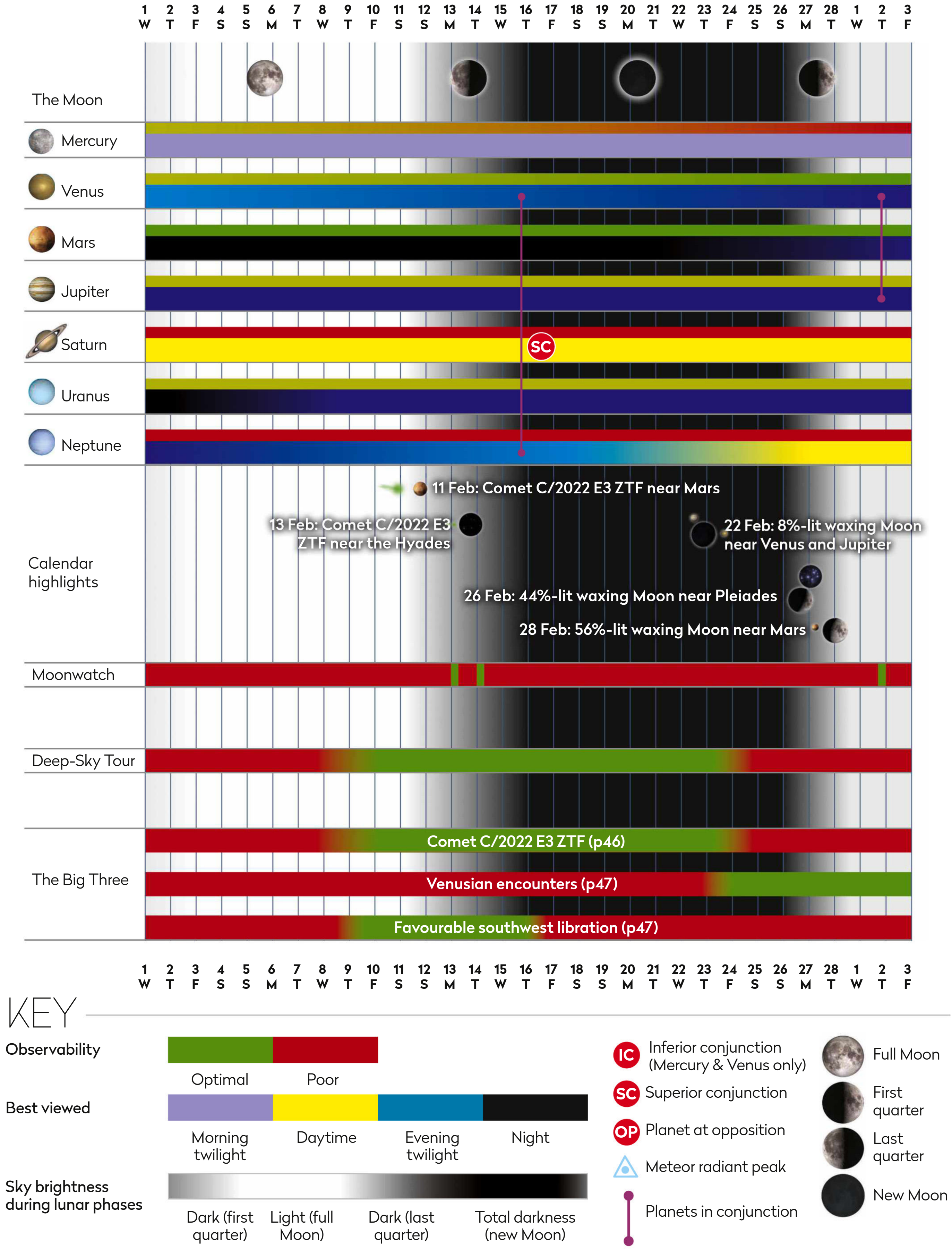

CHART BY PETE LAWRENCE


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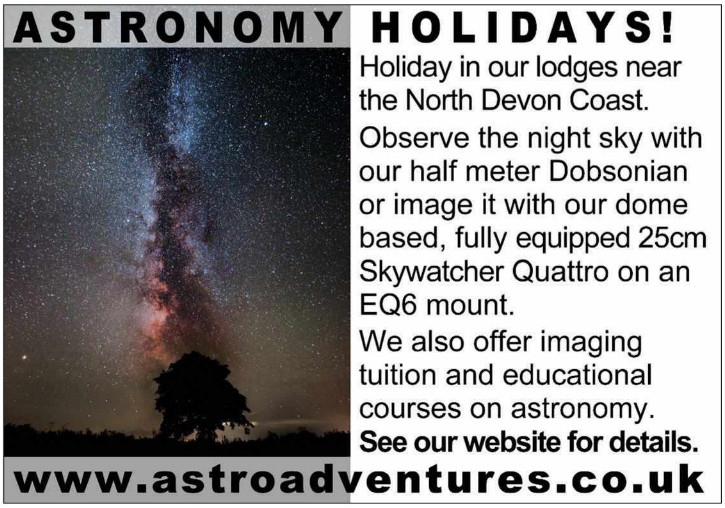
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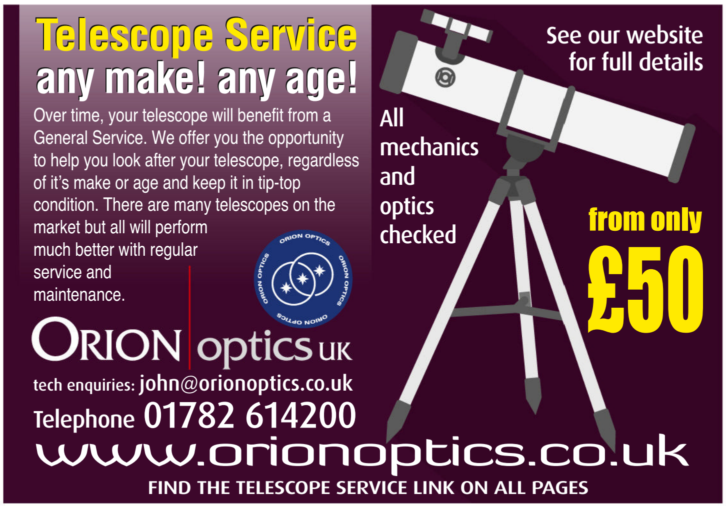
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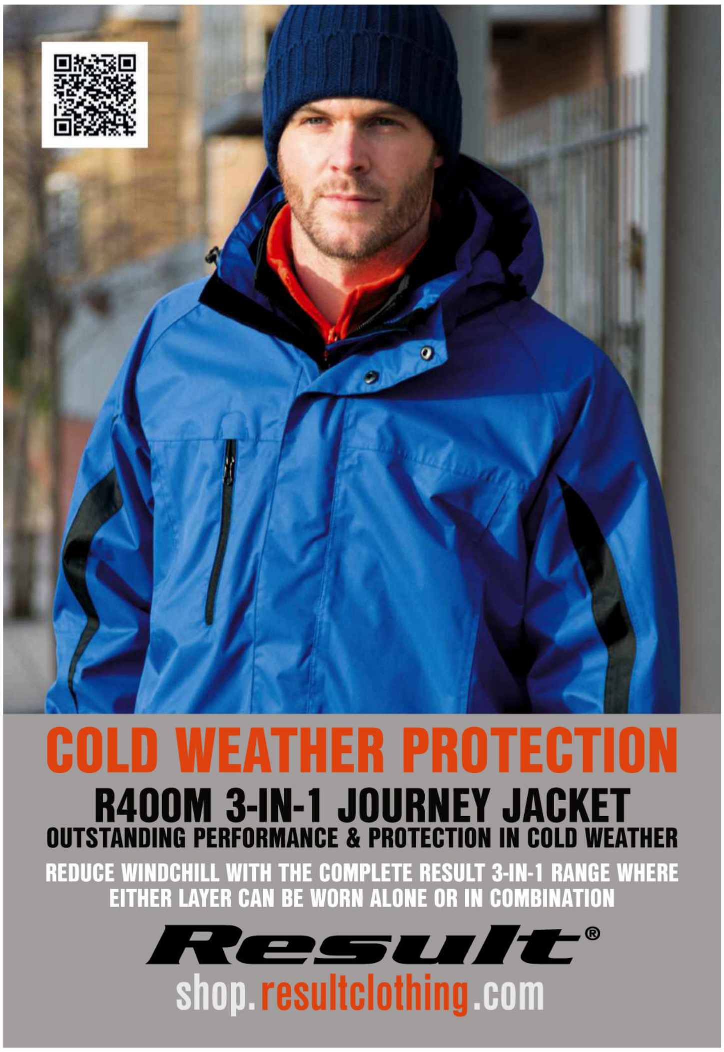
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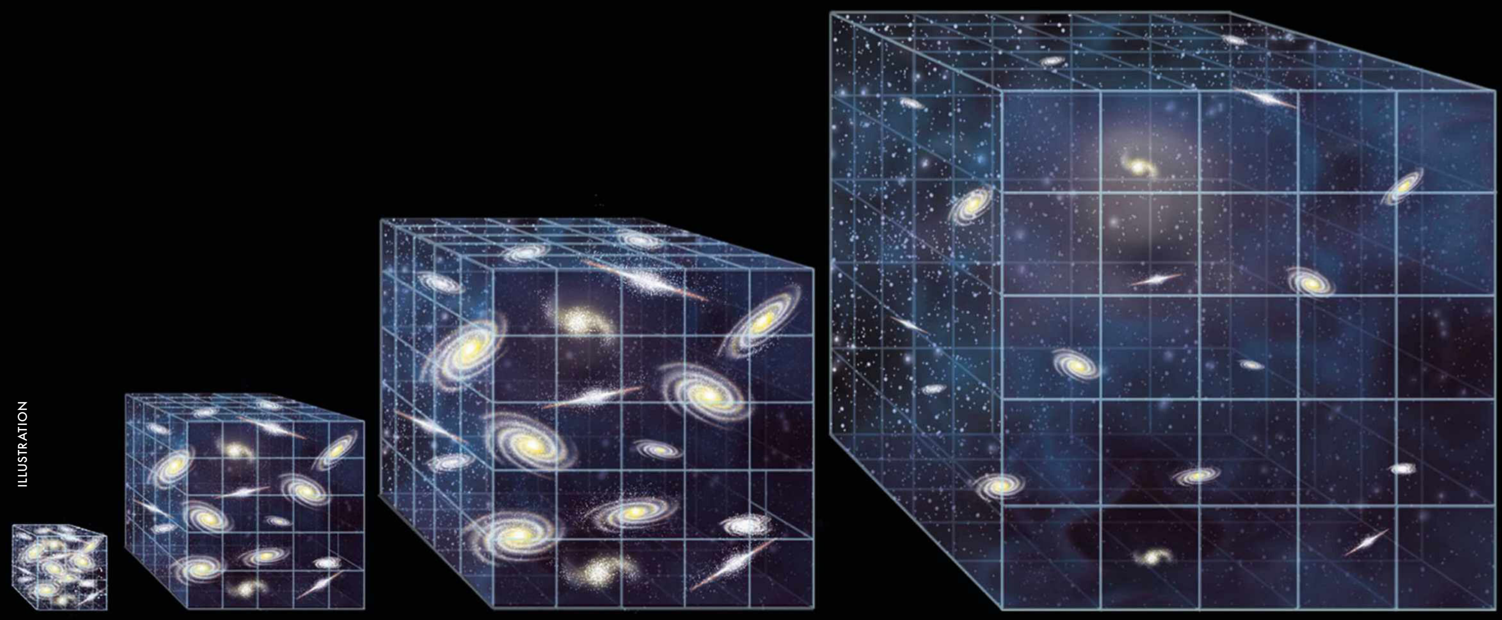


As the Universe expands, the galaxies within it move further apart

ILLUSTRATION

Does the Universe expand faster than light?

Govert Schilling continues to explain cosmology's confusing concepts in part 2 of our series

Our Universe is huge. In each and every direction on the sky, powerful telescopes observe galaxies whose light took more than 10 billion years to arrive at Earth. But wait – if we receive such ancient light from two opposite directions, and if the Big Bang happened 'just' 13.8 billion years ago, does that mean that the Universe is expanding faster than light? And wouldn't that violate Albert Einstein's theory of relativity, which says that the speed of light is an absolute limit?

The answer may surprise you. But first, we need to take a closer look at the expansion of the Universe. As described in the previous instalment of this series, we know that the Universe is expanding because galaxies appear to speed away from each other – their mutual distances are continuously increasing. But we also saw that cosmic expansion shouldn't be pictured as galaxies racing through empty space at incredibly high velocities. Instead, it is empty space itself that expands, pushing the galaxies ever further away from each other.

Govert Schilling's book *The Elephant in the Universe* is published by Harvard University Press

A useful comparison to help you imagine this scenario is to think about how a loaf of raisin bread rises in an oven. Although individual raisins don't travel around through the dough, they nevertheless end up further away from each other as the dough expands during the baking process. You get the picture: the dough is empty space; the raisins are the galaxies. Even if galaxies don't move around at all, their mutual distances will grow because of the expansion of space. (To represent an infinite Universe, the loaf of raisin bread would have to be infinitely large, but even then the rising dough would push the raisins apart.)

Speed of expansion

So what about the expansion velocity? Well, if two raisins start out at a distance of 1cm apart from each other, and the size of the bread increases by a factor of two in one hour, they will end up being 2cm apart. As a result, as seen from one raisin, the other one appears to be moving away at 1cm per hour. But a raisin that was originally further away, say at a distance of 3cm, will end up at 6cm,

Expansion and gravity

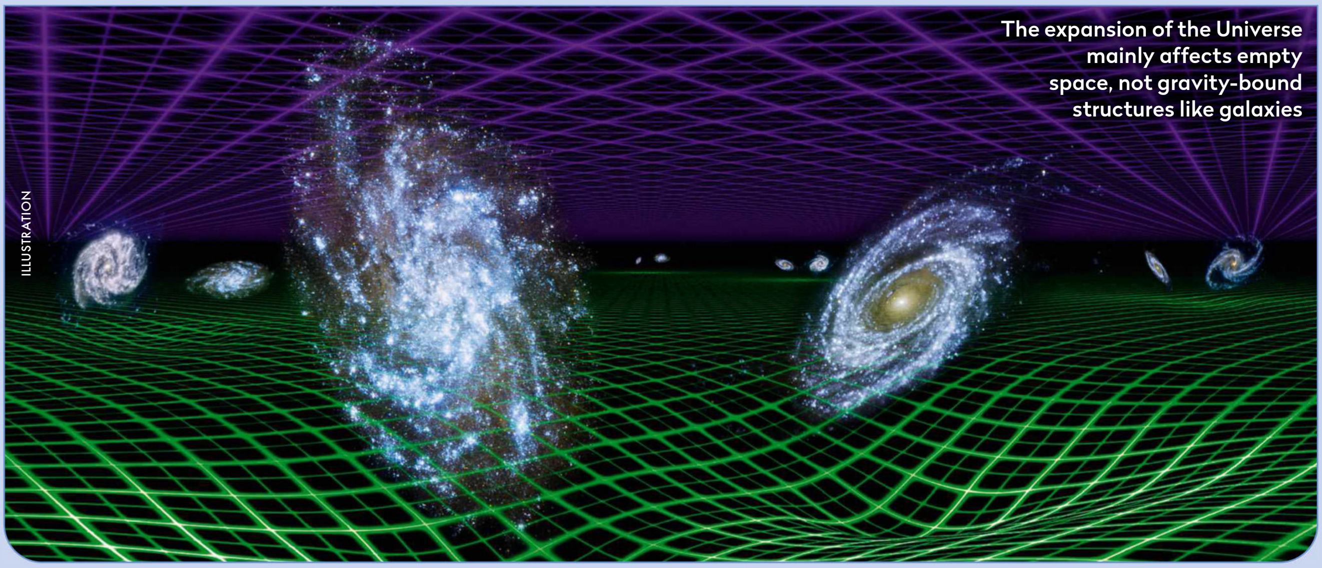
Though the Universe is expanding, gravity helps keep it together

If space is expanding, is our Milky Way galaxy growing bigger, too? Are the Solar System's planets slowly receding from the Sun? Is the diameter of Earth increasing? And what about ourselves?

Don't worry: relatively compact structures in the Universe are held together by their gravity – they don't expand. This is even true for groups and condensed clusters of galaxies. According to Albert Einstein's theory of relativity, massive objects affect the properties of empty space, including its curvature and rate of expansion.

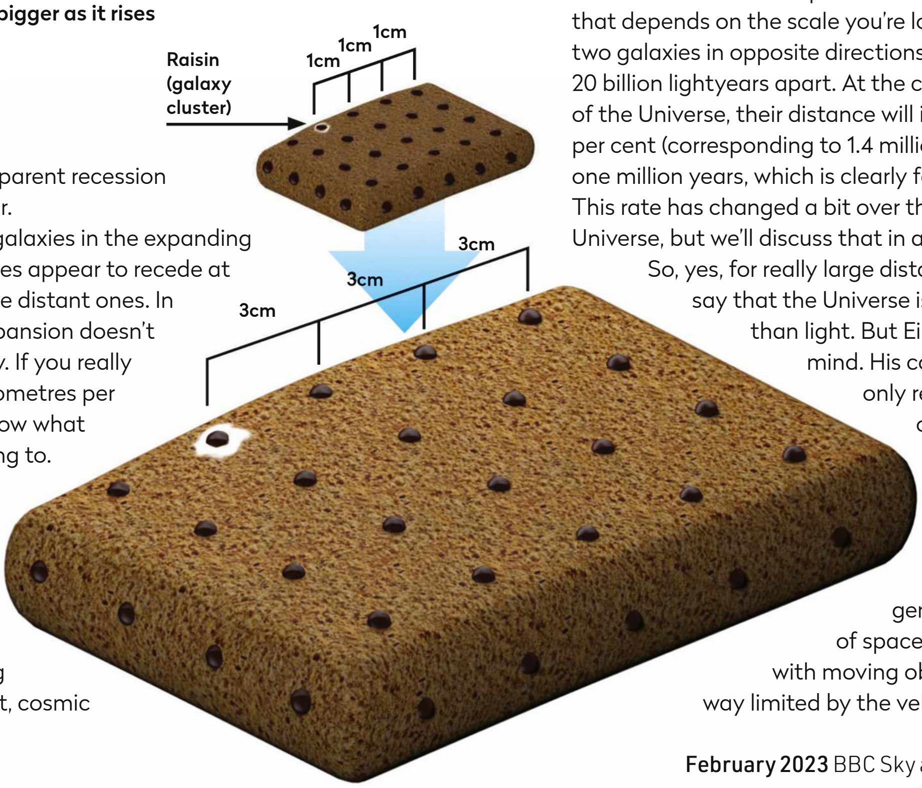
If we compare the expanding Universe with a loaf of raisin bread in which the raisins remain at fixed positions with respect to the rising dough (see main story), gravity could loosely be imagined as rubber bands connecting neighbouring raisins. Because of the rubber bands, the raisins resist being pushed apart from each other, which means that the dough does not easily rise in regions with higher density.

Likewise, the expansion of the Universe only plays a role outside groups and small clusters of galaxies. Our Galaxy, the Milky Way, and our Solar System and home planet are not affected. As for yourself: if you've grown more voluminous over the years, it's probably not because of the cosmos!



The expansion of the Universe mainly affects empty space, not gravity-bound structures like galaxies

▶ **As bread bakes, the raisins in the bread (like galaxies in our Universe) don't change size, but the dough (the space between galaxies) keeps getting bigger as it rises**



corresponding to an apparent recession velocity of 3cm per hour.

The same is true for galaxies in the expanding Universe. Nearby galaxies appear to recede at a slower pace than more distant ones. In other words, cosmic expansion doesn't have one single velocity. If you really want to express it in kilometres per second, you need to know what distance you are referring to. It's much more useful to quantify the expansion velocity of the Universe as a relative growth rate. It turns out that space is expanding pretty slowly: at present, cosmic distances increase by just 0.007 per cent in one million years.

Does the Universe expand faster than light? Well, that depends on the scale you're looking at. Suppose two galaxies in opposite directions on the sky are 20 billion lightyears apart. At the current growth rate of the Universe, their distance will increase by 0.007 per cent (corresponding to 1.4 million lightyears) in one million years, which is clearly faster than light. This rate has changed a bit over the lifetime of the Universe, but we'll discuss that in a future instalment.

So, yes, for really large distances you could say that the Universe is expanding faster than light. But Einstein wouldn't mind. His cosmic speed limit only refers to the motion of physical objects through space, from one point in the Universe to some other point. So in general, the expansion of space has nothing to do with moving objects, and is in no way limited by the velocity of light.

Betelgeuse (top left) is a variable star which has been known to alter the appearance of Orion, the Hunter, its host constellation

OBSERVING VARIABLE STARS

Pete Lawrence is your guide to viewing variable stars so you can record their changes in brightness

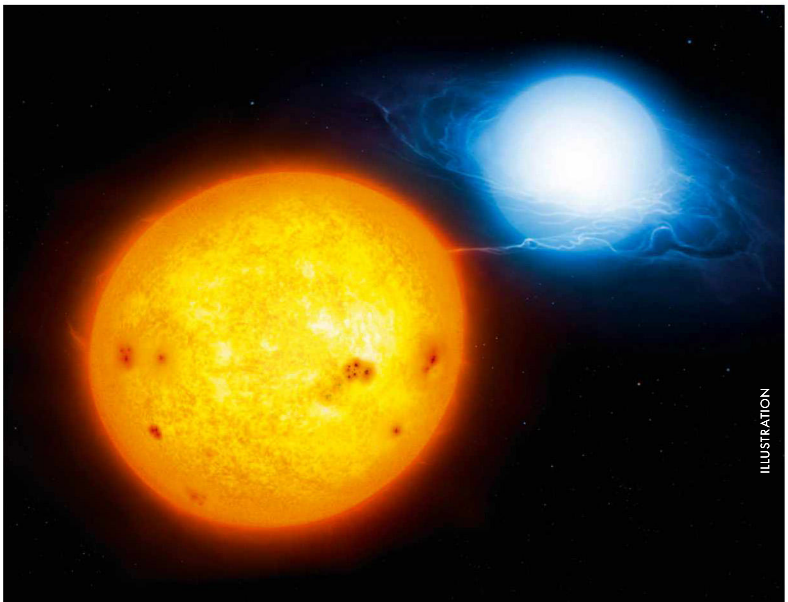
Although it may not be obvious at first sight, many stars vary in brightness over time. Some of these variable stars change magnitude on predictable timescales, others are less regular. Recording the variations is a rewarding and straightforward form of observing which ultimately helps decode how certain stars work. In this article we'll look at different types of variable, how to observe them and how to interpret the results. We'll also give you some examples to get you started.

A star's brightness is quantified by its magnitude. Some stars remain at constant magnitude, some vary a little and some vary a lot. Indeed, some stars become bright enough to change the visual appearance of their host constellation, such as Betelgeuse (Alpha (α) Orionis) and Mira (Omicron (ο) Ceti) (see 'Six variable stars to get you started' on page 66). Variability can occur on a predictable basis or can be highly irregular. The majority of variable stars appear to vary indefinitely, but some vary just once, with extreme examples being supernovae.

Variation in magnitude is either caused by external factors or by internal changes within the star; those in the first group are known as extrinsic variables, while those in the second are called intrinsic variables. An eclipsing binary such as Algol (Beta (β) Persei) is an example of an extrinsic variable; its observed brightness variation is due to a dimmer star passing in front of a brighter one with a very predictable period.

Many intrinsic variables pulse as a result of changes in the opacity of the star's outer layers. When the star is at minimum size, the outer layers are opaque and resistant to the passage of radiation from the star's fusion core. Consequently, the outer layers swell and as they do so their opacity drops and energy escapes more easily. The outer layers subsequently shrink back towards the core and the cycle repeats. Variations in the temperature of the outer layers, and their size, affect the star's luminosity.

▼ Algol is an extrinsic variable, where a dimmer star passes in front of a brighter one



Getting started

Stars with predictable variation are great to observe when starting out because they give you something to compare your results against. Don't research where the star should be in its cycle before you begin, though: observe it and determine the extremes yourself first. It'll give a great confidence boost when you discover you're in sync with other observations.

Less predictable, irregular variables take the subject to a new level and here you could be making cutting-edge observations of your own. Has the star done something odd? Is it brighter or dimmer than it should be? Based on the skill set derived from observing regular variables, you could be the first person to record something exciting.

Once you've built your variable star observing toolbox, you're set for the really unpredictable stuff such as eruptive variables, cataclysmic variables, flare stars, classical novae and ultimately supernovae. The last 'local' supernova occurred in the Large Magellanic Cloud, a dwarf satellite galaxy of the Milky Way, in 1987. Who knows when the next one will occur, but at least you'll be ready for it. There are ▶

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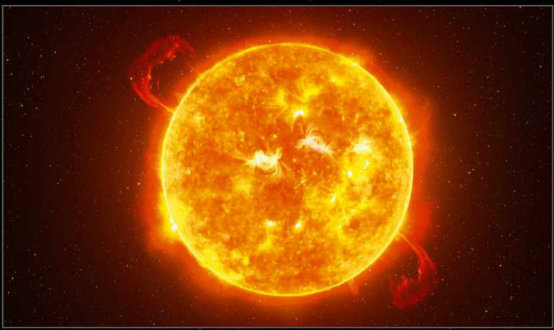
Types of variable star

Here's what's happening to cause changes in brightness in the most common variables

INTRINSIC VARIABLES Variability caused by internal factors



Eruptive variables

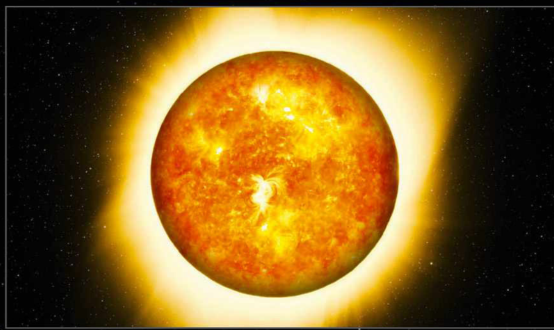
Output varies due to violent processes and flares within the star's surface and atmospheric layers. Examples include:
Gamma Cassiopeiae
FU Orionis
RS Canum Venaticorum
S Doradus
R Coronae Borealis and **UV Ceti**

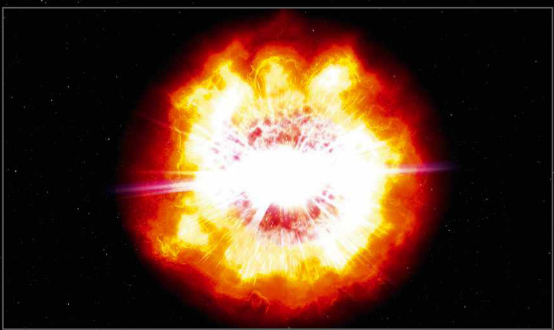
These include irregular variables and rapid irregulars. Some eruptives eject material into the surrounding space to interact with the interstellar medium. **Eruptive Wolf-Rayet** stars also come under this class: massive, highly evolved stars that continually eject gas into space.

Pulsating variables

Stars which grow and shrink their outer layers, often in periodic fashion. The processes are linked to the star's internal energy generation, swelling when heating up then shrinking when cooling, the cycle then repeating. Pulsation may be symmetrical (radial) or asymmetrical (non-radial).

Examples include:
Delta Cephei, the prototype of all Cepheid-type variable stars
RR Lyrae
ZZ Ceti
Mira, the prototype of Mira-type variable stars
Betelgeuse, a semi-regular pulsating variable.





Cataclysmic variables

Thermonuclear outbursts in a star's surface layers produce a nova or, when deep within a star's interior, a supernova. Novae are typically close binaries: a white dwarf with a giant, subgiant or dwarf companion.
U Geminorum and **SS Cygni** are examples of dwarf novae.

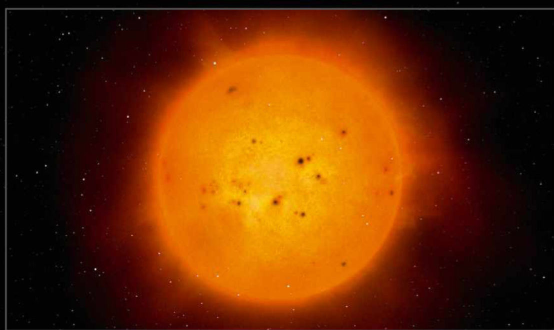
Supernovae show outburst brightening of 20 magnitudes or more, followed by a slow fade. This results in permanent physical changes to the star.
Type I are like novae, except the white dwarf is destroyed.
Type II result from a massive star (>8 solar masses) imploding.

EXTRINSIC VARIABLES Variability caused by external factors

Rotating variables

Stars with light and dark regions show variation as the star rotates. The regions typically result from intense magnetic fields causing hot-spots or starspots on the surface of the star. Examples include:
Cor Caroli
BY Draconis and **SX Arietis**

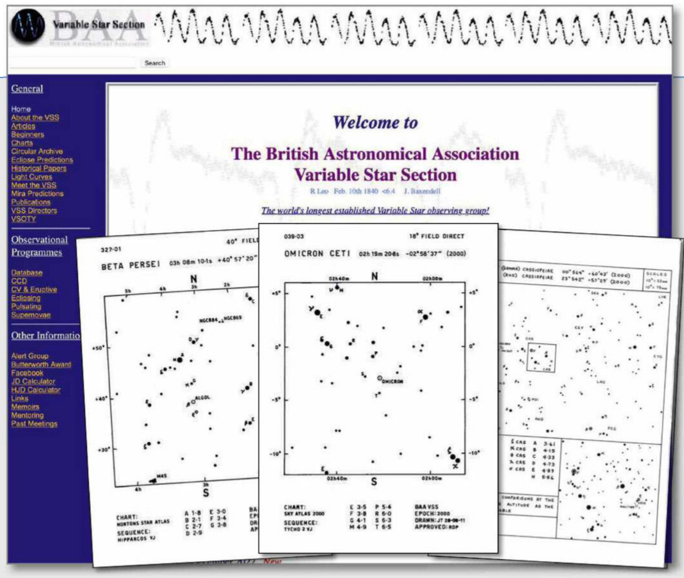
CM Tauri, the Crab Nebula pulsar, which is a rotating variable.
Spica, a non-eclipsing binary with elliptical components that change brightness depending on how they present to us.
AU Arietis, a close binary where the hot component's radiation reflects off a cooler companion.



Close binary eclipsing systems

These star systems appear to change brightness because the component stars eclipse one another as seen from Earth. Among the many examples are:
Algol
Beta Lyrae
RS Canum Venaticorum
and **Lambda Tauri**

Some, like **V0376 Pegasi** vary in brightness due to orbiting exoplanets. Unequal components produce a deep primary eclipse and a shallow secondary eclipse.
EW Ursae Majoris-type variables have comparable ellipsoidal components producing similar primary and secondary eclipses.



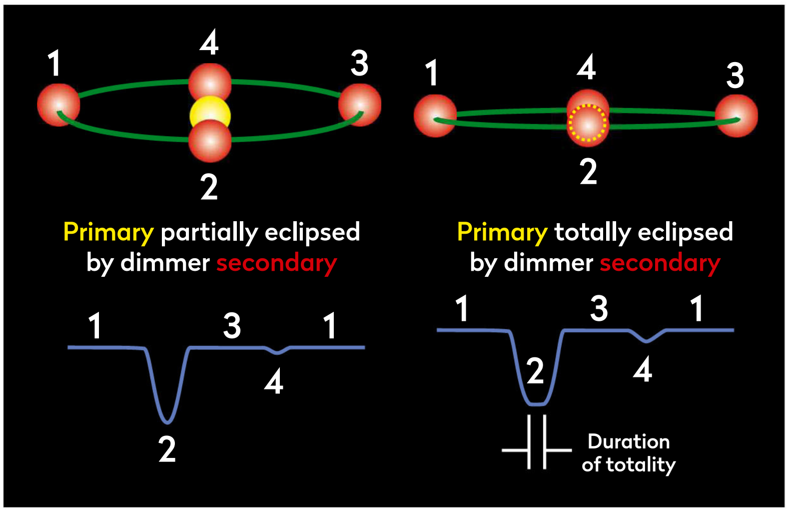
▲ The British Astronomical Association (BAA) offers variable star charts to help you estimate the variable's brightness

The fractional method

Use this technique to estimate a variable star's brightness if you're just starting out

Choose a variable star and find a reference chart for it via the BAA (British Astronomical Association, **britastro.org**) or AAVSO (American Association of Variable Star Observers, **aavso.org**). Both organisations have charts for variable stars which identify non-varying comparison stars to use when estimating the variable's brightness. Pick two stars, one brighter (A) and one dimmer (B) than the variable (V). If the difference in brightness between A and V equals that between V and B, V is mid-way between A and B, and you'd write that as 'A(1) V(1)B'; the brighter comparison is always presented first. If the difference between A and V were three times larger than that between V and B this would be written as 'A(3)V(1) B' and so on. You're mentally dividing the difference in brightness between A and B into a number of parts, in this example 4, and placing the variable along that scale.

If A's magnitude was +3.7 and the real difference between A and B was 0.4 magnitudes, each 'A(3)V(1) B' division represents 0.4 ÷ 4, or 0.1 magnitudes. In this example, V is 0.1 magnitudes brighter than B and 0.3 magnitudes dimmer than A, making it mag. +3.7 – 0.3, or +3.4. The magnitude difference between A and B should be less than 0.6.



▲ **Create a light curve for an eclipsing binary to discover if there is a partial eclipse (left) or total eclipse (right) of the primary star**

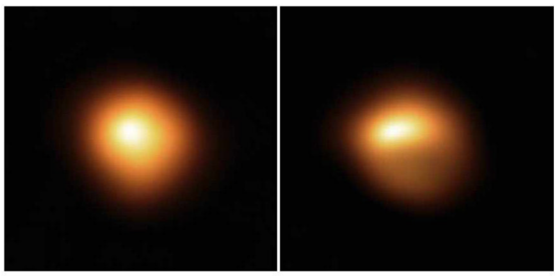
▶ many categories of variable star as we've shown on the opposite page.

The ultimate goal of variable star observing is to plot a star's light curve. There is nothing complex about this, it's basically a graph with time along the horizontal axis and magnitude along the vertical axis, but it can show a great deal about the variable. For example, create a detailed light curve for an eclipsing binary and the curve's shape will tell whether you are seeing a partial or full eclipse of the primary star. A partial eclipse shows a constantly changing curve, while a total shows a curve which 'bottoms out' at minimum brightness.

The longest period eclipsing binary is Almaaz (Epsilon (ε) Aurigae), with a period of 27 years. An eclipse dims the system from mag. +2.9 to +3.8, bottoming out for a couple of years, indicating a total eclipse of the primary. However, the brightness increases slightly mid-eclipse, before falling back to minimum again. One suggestion for this odd behaviour is that the secondary is a B-type star embedded in a thick obscuring disc of material aligned nearly edge-on to us. The minor peak occurs when the disc's central hole allows some of the primary's light through.

Learning from irregularities

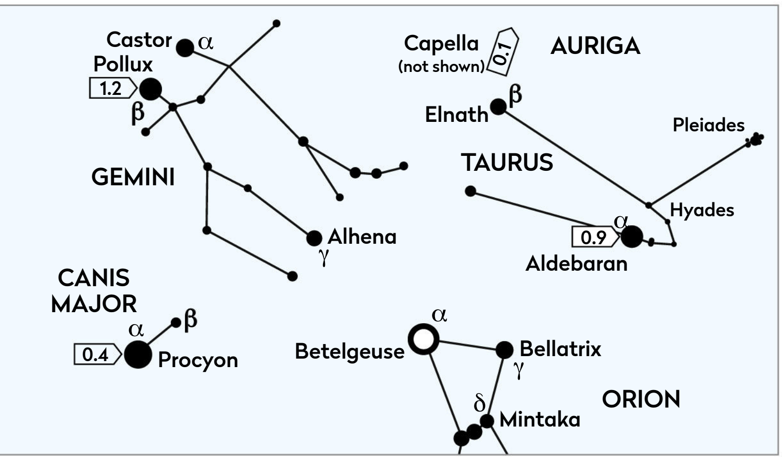
The light curves of irregular variable stars are extremely useful too. A long-period variable such as Betelgeuse (Alpha (α) Orionis) exhibits several periodic variations in brightness over different time spans and only by recording these over an extended period can the cycles be determined. In 2019 and into 2020 Betelgeuse became headline news as it unexpectedly faded. Known to be an old star close to the end of its life, this prompted many speculative predictions that the star was about to go supernova. It didn't and the variation in brightness was subsequently found to be due to cooler dust blocking the star's light. However, regular magnitude observations were in great demand over the fade period. ▶

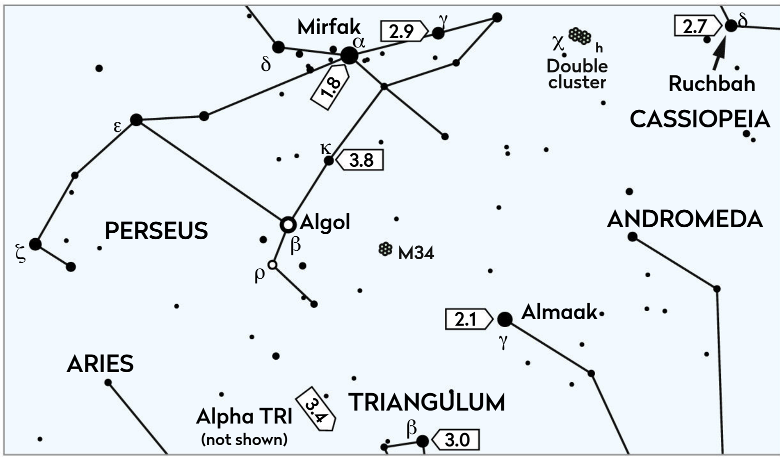


▲ Betelgeuse imaged in January 2019 (left) and December 2019 (right) showed a noticeable dimming

Six variable stars to get you started

These well-known variable stars are great to develop your observing skills on; their charts below have comparison stars' magnitudes labelled



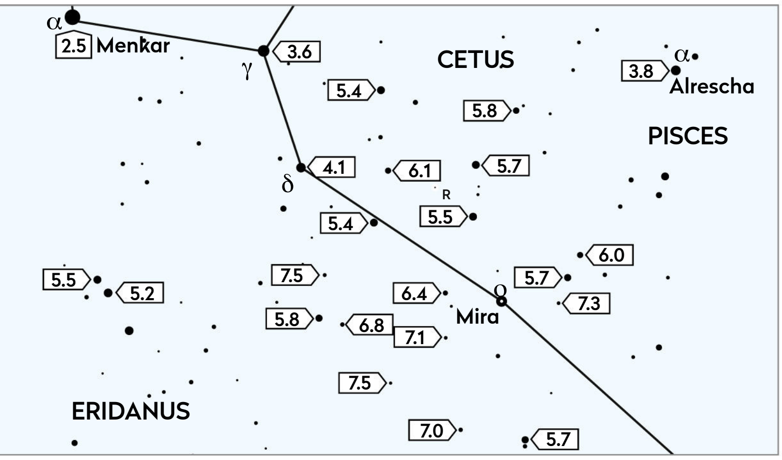


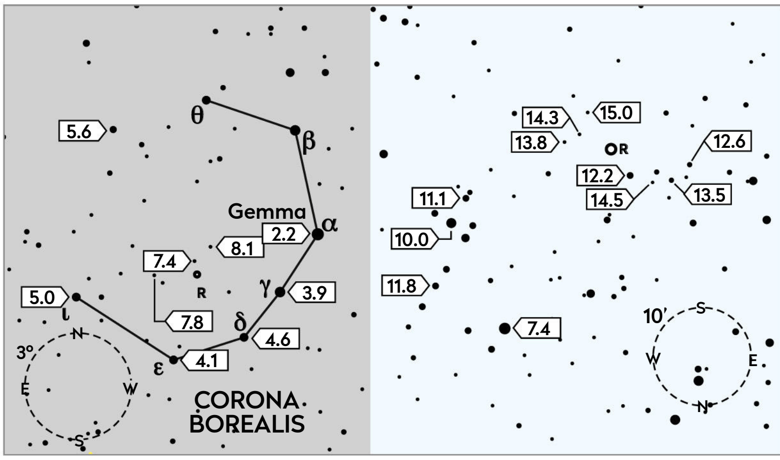
Betelgeuse (Alpha (α) Orionis)

An easy to find, long-period variable, sometimes tricky to estimate. It has semi-regular variation, typically mag. 0.0 to +1.6.

Algol (Beta (β) Persei)

An eclipsing binary system, which varies between mag. +2.1 to +3.4, with a period of 2.86 days.



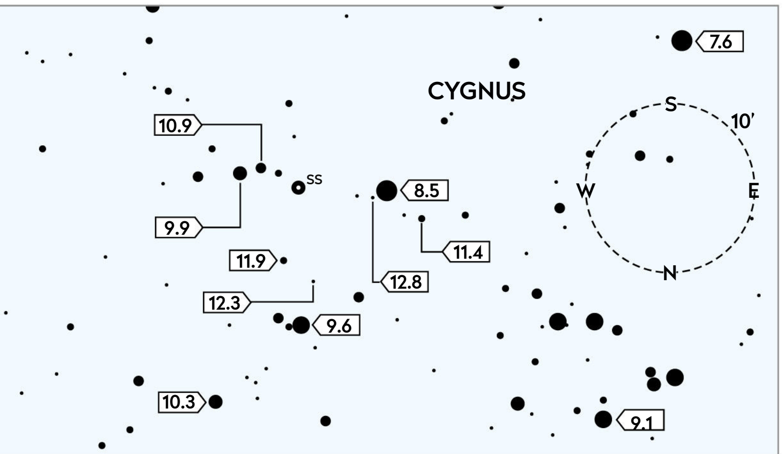


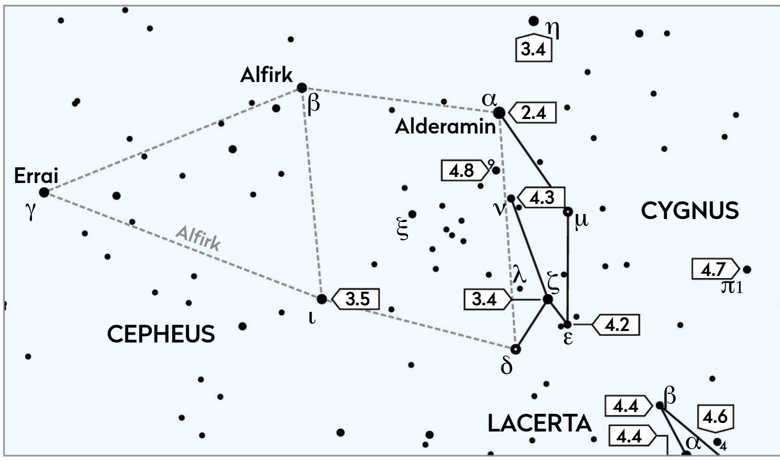
Mira (Omicron (ο) Ceti)

The prototype of Mira-type pulsating variables. The magnitude range is +2.0 to +10.1 but can deviate, with a period of 332 days.

R-Coronae Borealis (R CrB)

An irregular eruptive variable, with a typical magnitude of +5.7 to +14.8. Its light curve can be very unpredictable



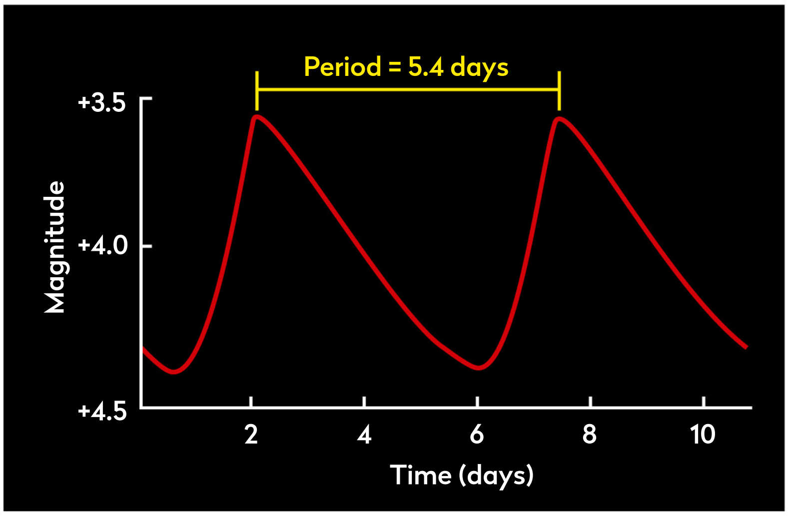


SS-Cygni

A dwarf nova, with a magnitude of +7.7 to +12, it typically peaks for 1-2 days every 7-8 weeks.

Delta (δ) Cephei

With a magnitude of +3.5 to +4.4 and a period of 5.3662 days, its rise to maximum brightness is faster than the following decline.



▲ A light curve for a Cepheid variable reveals regular periods of luminosity

▶ Cepheid variables, on the other hand, have light curves which show very regular periods. A ground-breaking discovery by Henrietta Swan Leavitt in 1908 showed the period to be directly linked to the star's luminosity. Basically, by determining the period of a Cepheid, you can determine how luminous it should appear. It's then possible to deduce how distant the star is in order to appear as bright as it does to us here on Earth. For this reason Cepheids became known as 'standard candles', and identified as an extremely important type of variable.

Although Betelgeuse is easy to see and a good starter, it also highlights a problem with red stars. Before we get to the reason why, let's take a look at some guidelines to follow to help you become an accurate and prolific variable star observer.

Before making any observation, let your eyes experience at least 20 minutes of complete darkness, subsequently avoiding any form of artificial light until the observation has concluded. The only exception would be dim red light for illuminating your log book in order to record your observations. Avoid using a computer or phone to record observations, as even a red screen's light plays havoc with dark adaptation.

We've already stated you shouldn't research details of a variable's state before making an observation. Doing so introduces bias which is bad science. Make the observation with a clear mind, recording whatever you see no matter how odd it may seem.

The issue with Betelgeuse applies to any star with a reddish tint, a common trait of intrinsic variables. The problem is that different eyes have different red-light sensitivities. Compare magnitude estimates of a red-hued variable to other results and you may find discrepancies. However, light curve shape should remain the same, along with total magnitude variation. Red stars also appear to brighten when viewed directly. This is awkward and the advice is to not stare at them for extended periods, instead developing a short glancing technique.

Other factors affecting variable star observations are sky quality, altitude above the horizon, and where the star and its comparisons sit in your field of view. Aim to move variables and comparison stars near the centre of the field of view when observing them.

Averted vision alert

When a variable is on the limit of visibility, it's natural to use averted vision to try and squeeze as much sensitivity out of your eyes as possible. This requires you to look to the side of the dim target so its light falls on a more sensitive part of your retina. When you become accustomed to looking at fainter objects through the eyepiece of a telescope, averted vision becomes second nature and you may not be aware you're even using it. However, for variable star observing, it's imperative to note when averted vision has been used. Averted vision may attribute a brighter magnitude to the star than it deserves, potentially skewing the result.

Once you're in the rhythm of observing variables regularly, you'll find the process quick and efficient. Start with a handful of easy targets, expanding the list as your experience grows. Submit your results to a recognised association such as the BAA (British Astronomical Association, **britastro.org**), where they will be put to good use.

Pete Lawrence is a skilled astro imager and a presenter on *The Sky at Night*

The Pogson step method

A technique to use when you are confident in estimating small changes in brightness

With experience, you should be able to visually estimate magnitude differences as small as 0.1. When you're confident you can do this, consider using the Pogson step method.

Here, you choose a comparison star close in brightness to the variable (V) and estimate how many tenths of a magnitude it is brighter or dimmer. If you saw comparison star D was 0.2 magnitudes dimmer than V, you'd write this as 'D-2'. It's regarded as good practice to use more than one comparison to help smooth results and eliminate errors. For example, if you saw star C being 0.3 magnitudes brighter than V, write it as 'C+3'.

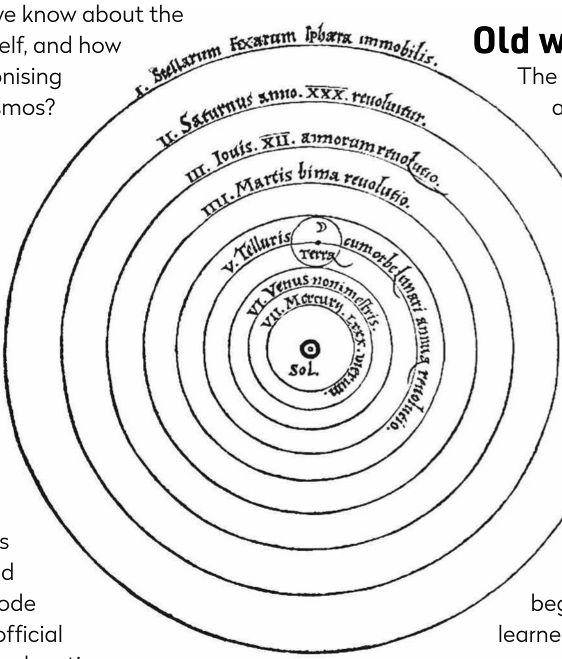
After your observation you can use the magnitude table on your chart of the variable to determine the magnitudes of C and D, and then work out the two values for V. If they don't quite match, average and round off if necessary. For example, if C is mag. +5.8, and D is mag. +6.2, this gives V a magnitude of +5.8 + 0.3, or mag. +6.1 from comparison star C; and +6.2 – 0.2, or mag. +6.0 from comparison star D. Take the average (+6.1 + +6.0) ÷ 2, to get +6.05, and round it off to get +6.1. If the variable can't be seen, identify the faintest comparison star, for example F, and write the observation as '<F'.

The man who put the Sun at the CENTRE OF THE UNIVERSE

This month marks 550 years since the birth of Nicolaus Copernicus. **Emily Winterburn** explores his life and legacy

Today, Nicolaus Copernicus is a household name, well known as the astronomer who gave us the Sun-centred model of the Universe. But what do we know about the man himself, and how did he go about revolutionising our perception of the cosmos?

Nicolaus Copernicus was born in Poland on 19 February 1473 and came from a wealthy, well-connected family. His father was a merchant, as was his maternal grandfather. The family had many connections to the Catholic Church which, at the time, put them in a powerful position in Poland. When Copernicus was 10, his father died and his uncle, Lucas Watzenrode – a high-ranking church official – took over control of his education. He was sent to a church school and then to the University of Kraków. European universities back then were places to train wealthy men to join the professions: law, church and medicine. Indeed, his studies at universities in Poland and Italy included these disciplines.



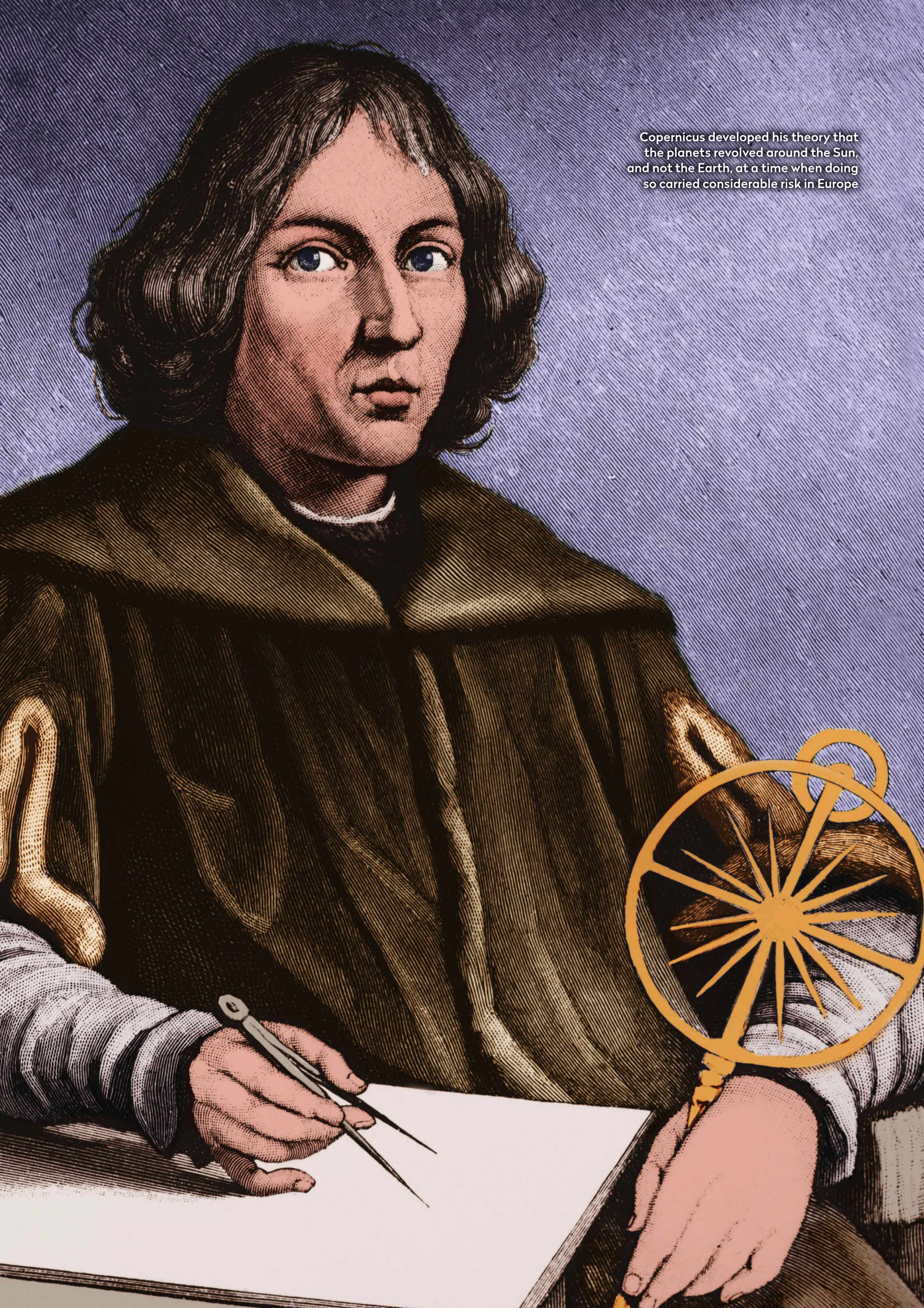
▲ **Copernicus's heliocentric model of the Universe, as presented in *De revolutionibus orbium coelestium***

Old world order

The academic world of the 1400s and 1500s was very different to the world we know today. No one could study a degree in astronomy, and astrology was seen as a legitimate and important scientific subject. In Kraków, Copernicus began reading about astronomy and probably attended lectures by members of the Kraków School of Mathematics and Astrology. Even when he began studying medicine, he learned yet more astrology, as this was an integral part of medical knowledge at the time.

By the time he was 30, Copernicus had finished his studies and began ▶

SCIENCE HISTORY IMAGES/ALAMY STOCK PHOTO



Copernicus developed his theory that the planets revolved around the Sun, and not the Earth, at a time when doing so carried considerable risk in Europe

▶ working for his well-connected uncle as a secretary and physician. When his uncle, Watzenrode, died in 1512, Copernicus moved to Frombork on the Baltic Coast, which became his home for the rest of his life. At Frombork he continued reading about astronomy, which at the time still held to Aristotle's model of the Universe, with the imperfect Earth at the centre surrounded by perfect, heavenly spheres. He observed the night sky, developing his ideas as he recorded his observations of planets and eclipses. He took up administrative and advisory roles within the church and state, and then in 1514 he wrote his first piece outlining his heliocentric model of the Solar System. This first draft, intended only for close friends and acquaintances, was called *Commentariolus*.

Changing views of the cosmos

Copernicus was very cautious about his theory and the potential upset it could cause, as Aristotle's model was the one adopted by the church. This included Ptolemy's addition of 'epicycles' (each planet moving in a small circle while on its larger orbital circle) to better account for the actual, observable movement of the planets, particularly retrograde motion. For a long time, Europeans stuck with this model. In the Islamic world, however, many mathematicians and astronomers were questioning and adjusting this model to make better sense of it. From the work cited in Copernicus's texts we know that he was aware of at least some of these theories as he went about developing his own.

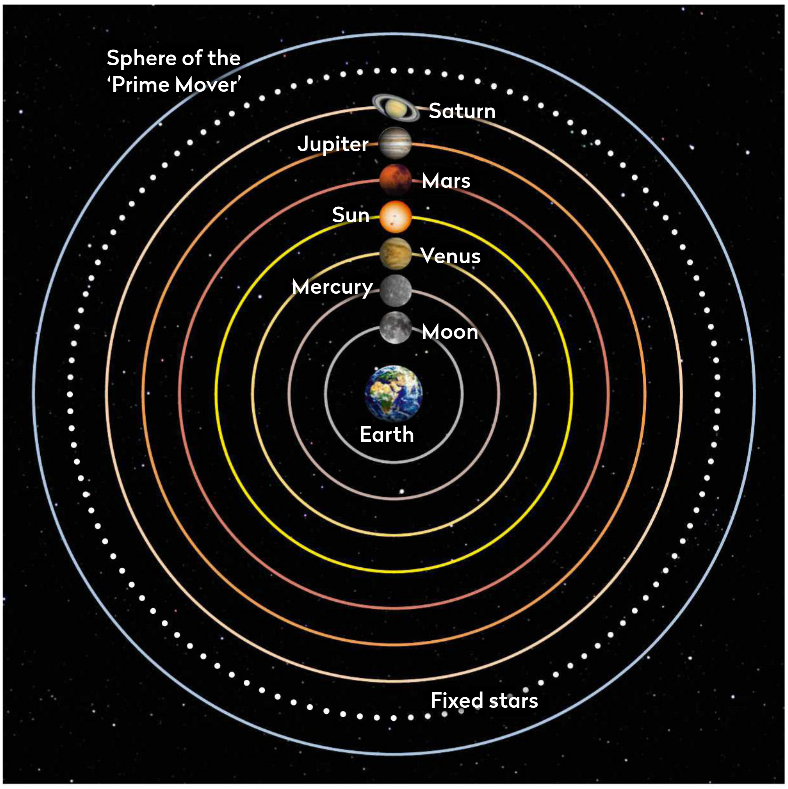
Due to a lack of primary sources, historians can only speculate on how Copernicus arrived at the heliocentric model. However, it's generally agreed it was a combination of observing planets in the early 1500s at his observatory in Frombork, and careful analysis of planetary models, including those from the Islamic world, coupled with a philosophical desire for simplicity. All those epicycles needed to account for retrograde motion were getting in the way of a neat, simple, useful mathematical model.

As *Commentariolus* circulated among his acquaintances, Copernicus carried on with his work, collaborating with other Kraków astronomers on the observation of eclipses. He took part in discussions about the reformation of the Julian calendar, which would eventually lead to the adoption of the Gregorian calendar we use today. He was beginning to develop a reputation too as distant and aloof, a scholar with a dark and questionable secret theory – at least that's how he was caricatured in the play *Morosophus* ('The Foolish Sage').

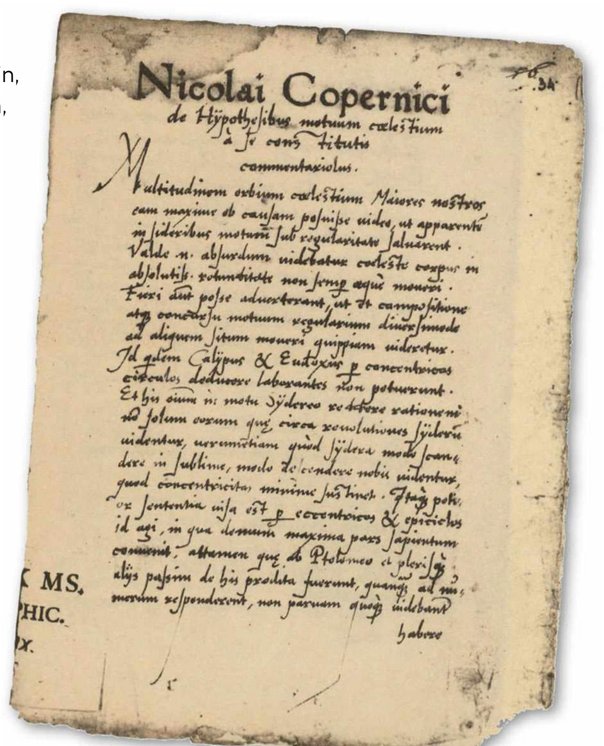
By 1532 Copernicus had finished writing *De revolutionibus orbium coelestium* ('On the Revolutions of the Celestial Spheres'), but was still not ready to publish. A year later, his friend Johann Albrecht Widmanstetter, secretary to Pope Clement VII, explained Copernicus's theory to the Pope and two cardinals, and they found it most interesting. Although still not published, more educated people around Europe began to learn about the theory.

In 1543 Copernicus was eventually persuaded to publish, but he did so extremely cautiously. He dedicated the book to Pope Paul III, and his printer Andreas Osiander wrote a preface explicitly explaining that the model should be seen as a mathematical tool or model, rather than a representation of what was actually there. The book was written in Latin, the language of the rich, educated elite and was not accessible to the general population.

Copernicus's precautions, and long-standing association with the church, paid off. Not everyone was convinced, but disagreements were mathematical and scientific rather than theological. Tycho Brahe, the Swedish astronomer (born not long after the book came out), found Copernicus's model unsatisfactory and came up with his own, which fits the same data but keeps Earth at the centre.



▲ Copernicus turned the Aristotelian concept of the Universe on its head. Aristotle's model (above) had placed Earth at the centre, with an outermost sphere where the motion of the 'Prime Mover' was imparted from sphere to sphere



▲ *Commentariolus*, written in 1514, set out Copernicus's heliocentric theory

Timeline: A life of revolutions

The story of Copernicus's life has been pieced together from limited sources. Only 17 of the letters he wrote in his lifetime survive, and he left little by way of personal papers. Instead, we have manuscripts and published editions of his printed works as well as public records of births, deaths and appointments.

1473
Copernicus is born, of German parents, in a city in northern Poland, Torun.

1491
Enrolling at the University of Kraków, his studies include mathematics.

1495
His uncle, Lucas Watzenrode, arranges a church admin position for him.

1496
Copernicus goes to the University of Bologna, to study canon (religious) law.

1497
He observes an occultation, as the Moon eclipses the star Aldebaran.

1501
He goes to the University of Padua to study medicine (with astrology).

1503
In Frombork, Copernicus works for his uncle as a physician.

1514
Copernicus writes *Comment-ariolus* ('Little Commentary').

1532
He writes his landmark *De revolutionibus orbium coelestium.*

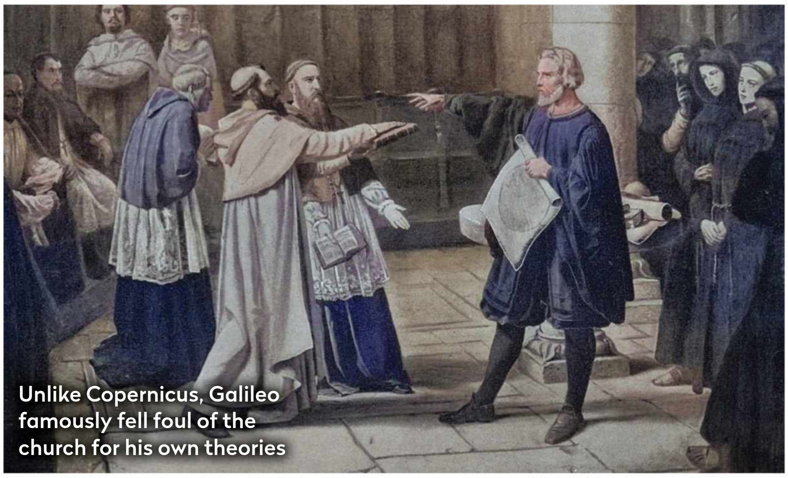
1533
His ideas are presented to the Pope who expresses an interest in them.

1543
De revolutionibus orbium coelestium is published.

1543
Copernicus dies in Frombork, aged 70, and he is buried in the city's cathedral.

1583
Tycho Brahe puts forward his alternative model of the Universe.

1610
Galileo Galilei publishes his support of the Copernican model.

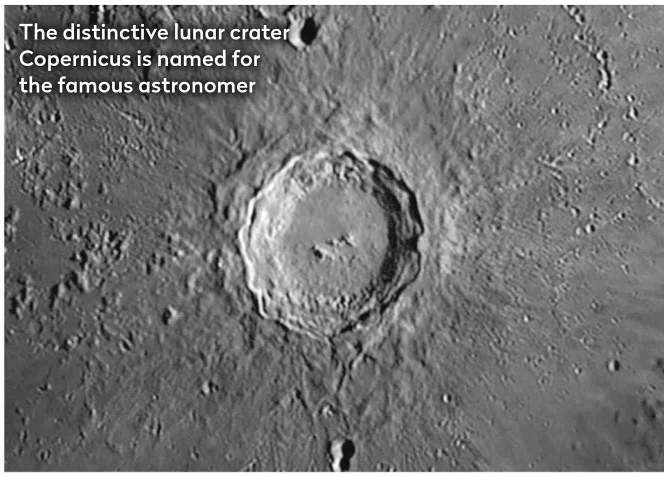

Unlike Copernicus, Galileo famously fell foul of the church for his own theories


Emily Winterburn is an astronomy historian and author

In his, the planets orbited the Sun and the Sun and Moon orbited Earth. Though Brahe was pleased to have kept Earth at the centre of the Universe, his model was not to last. Observations and theories by his assistant Johannes Kepler, and later still Galileo Galilei, showed Copernicus's model to be a much better fit.

Galileo famously received a very different reception to Copernicus, and there were several reasons for this. Galileo made much less effort to appease or appeal to the church than Copernicus. He did not try to present his heliocentric ideas in a way they would find reassuring, nor did he limit his readership by only writing in Latin. The church was also much less sure of its absolute power by the 1600s, given the rise of Protestantism, and less willing to tolerate criticism.

Today, Copernicus's name is synonymous with astronomy. His face has been on banknotes and stamps and he features in every timeline on astronomical history. He even has a crater on the Moon named after him. And that's not forgetting the European Space Agency's Copernicus programme, which helps us better understand and mitigate the effects of climate change by observing Earth from space. In his own time Copernicus was able to present challenging scientific ideas to the powers that be in a peaceful and productive way. Perhaps through ESA, his namesake will be able to do the same.

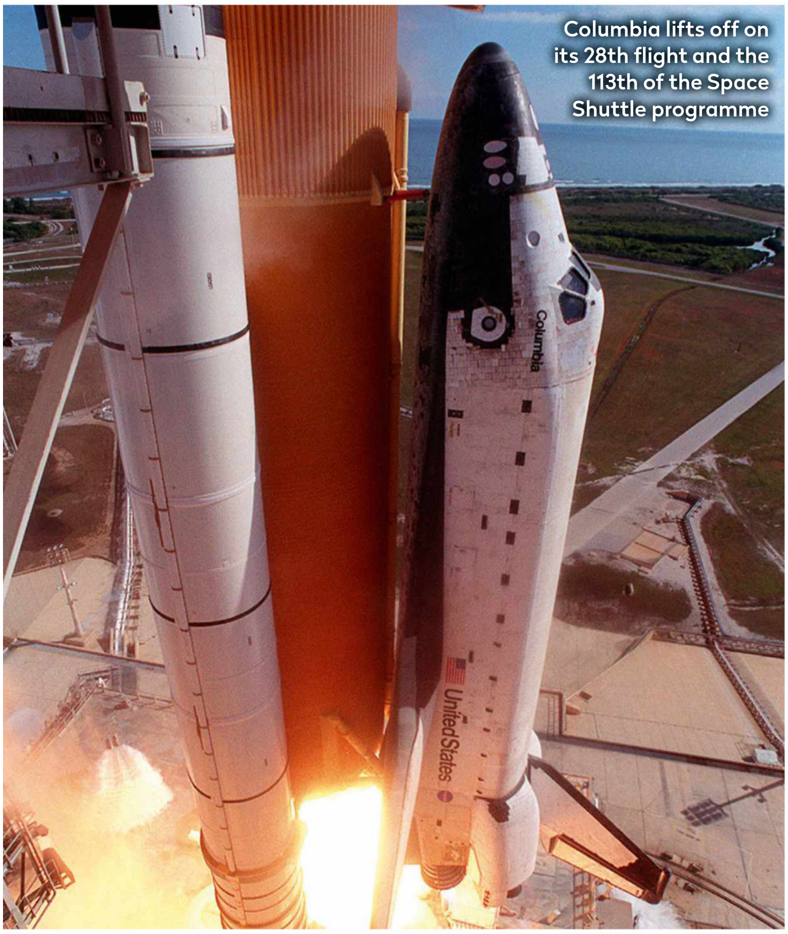

The distinctive lunar crater Copernicus is named for the famous astronomer

The fundamentals of astronomy for beginners

EXPLAINER

The Columbia Space Shuttle disaster

Twenty years on, **Amy Arthur** looks back at fateful flight STS-107



Columbia lifts off on its 28th flight and the 113th of the Space Shuttle programme

NASA's Space Shuttle programme ran from 1972 to 2011, its successes including the launch of the Hubble Space Telescope, Spacelab and the construction of the International Space Station.

But the programme had its problems. Schedule pressures and tight budgets had been blamed for the loss of one of its five orbiters, Challenger, and its seven-person crew in 1986. Organisational changes were made, but by the launch of Columbia's flight STS-107 on 16 January 2003, problems had returned.

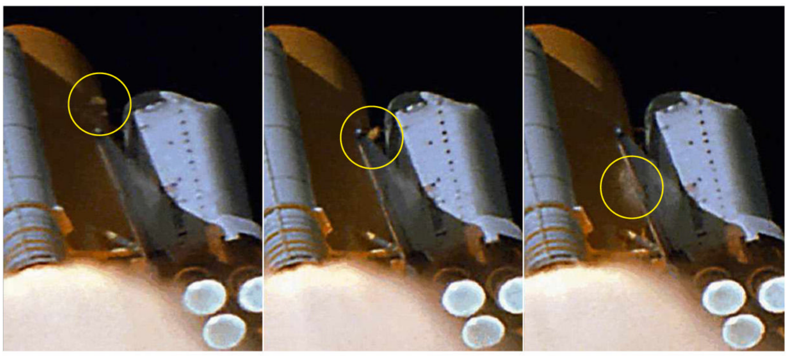
Initial reports after launch were positive, and the crew looked forward to the 16 days of scientific research ahead of them. On the ground, a team reviewing launch footage noticed that something had fallen from Columbia's fuel tank and struck the underside of its left wing, where reinforced carbon-carbon panels would act as a heat shield against the 1,600°C endured during re-entry to Earth.

The object was a piece of insulating foam, roughly 60cm by 38cm, with an impact speed of 877km/h. Smaller foam strikes were common on Shuttle missions, but to assess whether the damage posed a real threat, the team requested high-resolution images from the US Department of Defense. This request, and the two more submitted in the week following, were denied.

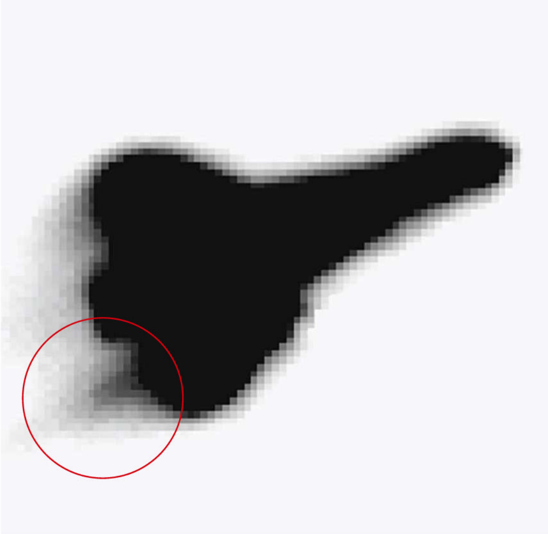
"Absolutely no concern"

Management, aware that orbiters had survived foam strikes previously, concluded Columbia's situation posed a "known and acceptable risk". The crew were finally notified on 23 January. Mission control assured them there was "absolutely no concern for entry".

By 1 February, when Columbia began its return, the STS-107 flight team were not expecting problems. But after entering Earth's atmosphere at 8:44am (Eastern Standard Time), the left wing's heat shield began to fail. At 8:48am, sensors detected abnormally high temperatures, but these readings were not received by Mission Control. Onlookers began to see debris shedding from Columbia at 8:53am. As far as NASA knew, things were going smoothly.


▲ A piece of foam was seen breaking off and striking the Shuttle's left wing, where the heat shields – crucial for the crew's survival at re-entry – were located

NASA X 5



▲ **Above left: A shot taken from the ground shows debris trailing as Columbia begins to disintegrate**

Above right: Wreckage gathered for the official investigation

At 8:54am, the ground flight director was told "off-scale low" readings were appearing for four sensors in the left wing, but no action was taken. On board, the crew were unaware of the rising temperatures and increasing drag in the wing. At 8:59am, readings were lost on two landing gear tyres.

At 8:59:15am mission control informed the crew of the problem. A response at 8:59:32am from mission commander Rick Husband began: "Roger —" before communication with Columbia was lost entirely.

The disintegration of Columbia was captured in photos taken by people on the ground waiting to see the astronauts return home. At 9:16am, the orbiter's scheduled landing time, NASA declared a 'Shuttle Contingency' plan. Within two hours the Columbia Accident Investigation Board (CAIB) had been formed. Later, President Bush addressed the nation: "Columbia is lost. There are no survivors."

In the weeks that followed, the debris search covered over 2,000 square kilometres. Over 84,000 pieces were found: around 38 per cent of the orbiter. Debris, phone and email data, meeting transcripts, images and files from NASA were collected by the Board for its seven-month-long investigation.

The question on everyone's minds was: could this have been prevented? Could Columbia have been repaired, or the crew rescued? While repair was deemed possible using the equipment the crew had on board, NASA wasn't confident that it would have survived the strain of re-entry. The Shuttle Atlantis, however, could have been hurried to launch for a rescue mission, but this may have led to a similar foam strike, and would have stretched Columbia's power and resources thin. It would have been feasible, had NASA made the decision within seven days of the foam strike, CAIB concluded.

Following the report, NASA made improvements, including keeping a designated rescue mission ready for future flights. The Space Shuttle programme, grounded immediately after the Columbia disaster, resumed in 2005, ending officially in 2011. It had cost NASA $211 billion, and the lives of 14 astronauts.

Amy Arthur is a science writer and speaker

The crew of Columbia flight STS-107

1. Mission specialist David Brown
Born: 16 April 1956
Flights: STS-107
Former surgeon with the US Navy. Brown had been trained to fly NASA's supersonic jet, the T-38.

2. Commander Rick Husband
Born: 12 July 1957
Flights: STS-96, STS-107
Piloted the first ever ISS Shuttle docking during his first flight in 1999, on board Discovery.

3. Mission specialist Laurel Clark
Born: 10 March 1961
Flights: STS-107
Clark was a surgeon with the US Navy. Joined NASA in 1996 and was assigned her first and only mission on STS-107.

4. Mission specialist Kalpana Chawla
Born: 17 March 1962
Flights: STS-87, STS-107
Obtained a doctorate in aerospace engineering, then worked at NASA Ames Research Center. First woman of Indian origin to fly in space, on flight STS-87.

5. Payload commander Michael Anderson
Born: 25 December 1959
Flights: STS-89, STS-107
Joined the US Air Force after completing a degree in physics and astronomy. First flight with NASA in 1998 on Endeavor.

6. Pilot William 'Willie' McCool
Born: 23 September 1961
Flights: STS-107
Joined NASA in 1996, performing technical roles until chosen for his first and only spaceflight, STS-107.

7. Payload specialist Ilan Ramon
Born: 20 June 1954
Flights: STS-107
Colonel and fighter pilot with the Israeli Air Force, and Israel's first astronaut.

Practical astronomy projects for every level of expertise

DIY ASTRONOMY

Build a zero-magnification finder

Make an illuminated aiming device you can use on any telescope

By mounting the finder with a camera ball joint, it can be aligned with the main scope

This month's project helps you aim your scope at a target in the night sky. It is called a zero-magnification finder because the view is the same size as seen with your naked eye. The finder projects a red circle onto the background sky and you move your telescope to align the centre of this circle with your target. Many stargazers use similar devices because they allow you to keep both eyes open and see a much larger area of sky, making it easier to jump to the target.

Our design has a red LED that illuminates the white interior of the front of the case. The LED is powered by a coin cell battery, via a switch on the back panel. The red light is reflected backwards through a clear glass screen, painted matt black except for a small ring in the centre. The light is then reflected upwards by a mirror mounted at 45° and through a lens, which produces a sharp image. This is reflected backwards again by a glass viewing screen, mounted at 45° in a hood. When the distant sky is viewed through this screen, the red circle is superimposed on it.

We sourced the components for this project imaginatively to keep the cost down. The LED, coin cell holder and switch are from an educational supplier. The clear glass was cut from an old picture frame, and we used the frame's thin MDF backing to make the case. The front surface mirror is a disposable dentist's mirror. We found these online, along with the lens, a Fresnel magnifier sheet.

Mark Parrish is a bespoke designer based in West Sussex

Mounting matters

Cutting glass is easy – score with a glass-cutting wheel and snap over a straight edge – but it is advisable to dull the resulting sharp edges by rubbing on a flat stone. Alternatively use clear plastic, which can be cut from an old CD case.

Once you have made your finder, you'll need to mount it and align it with your telescope. We used a camera ball mount for this. The top screw passes through a hole in the bottom of the case. Use a ¼-20 nut to fix it. Alternatively, a blob of hot glue will suffice. To attach the ball mount to the scope, use a ¼-20 stud (some mounting rings have screw-threaded holes for attaching accessories), or improvise with a large pipe clip or cable ties to hold the hot shoe part of the ball mount. Point the scope towards an easy-to-find bright star or planet, loosen the ball mount and align the projected red circle with the same target. Once aligned, you can use the finder (along with your *Sky at Night Magazine* all-sky chart on page 50) to hop around the sky with ease.

MORE ONLINE

Find additional photos and download diagrams to help with your build. See page 5 for details

What you'll need

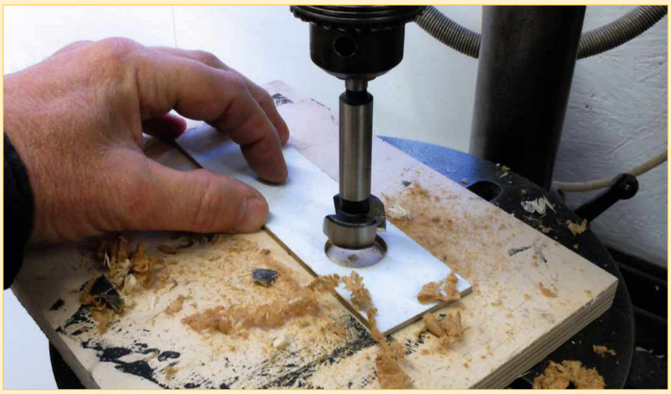
- Ruler, square and pencil for marking out.
- Coping saw, junior hacksaw, drill, drill bits, glass cutter, cutting mat, soldering iron.
- Small sheet (approximately A4 size) of thin MDF or plywood; small piece of thin glass or clear plastic; small metal ring (8–15mm or so in diameter).
- Red LED, 3V coin cell battery, battery holder, toggle switch (single pole, single throw), short length of electrical wire.
- Dentist's mirror, Fresnel credit-card-sized magnifier.
- Camera ball mount.
- Spray paint, glue (we used a hot-glue gun), black paint, white paint.

ALL PICTURES: MARK PARRISH

Step by step

Step 1

Carefully mark out the MDF (use our downloadable plans to work out the sizes). Cut out all the parts with a coping saw or similar, then sand the edges smooth. We used 3mm MDF, but any thin board should work. Keep close to our suggested dimensions.

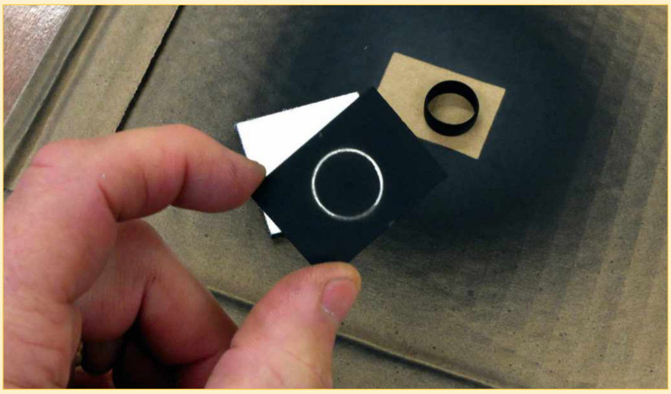


Step 2

Carefully drill the holes in the panels. You need a hole of approximately 20mm diameter for the reticule aperture and a similar size for the top of the main case. This could be cut with a coping saw if you don't have a large drill.

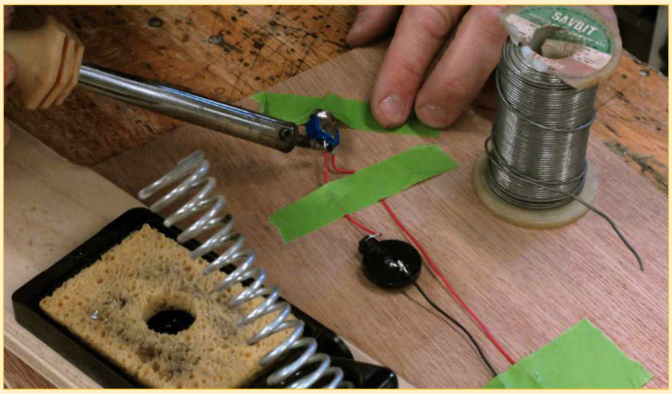
Step 3

Carefully cut the glass for the reticule and viewing screen. Use a glass-cutting wheel to score a line, then press down over the edge of a ruler to snap it. We used a flat stone (normally used for sharpening chisels) to dull the sharp edges.



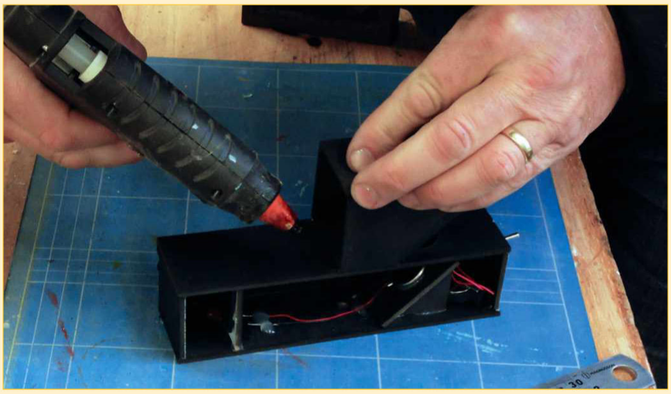
Step 4

Place a small metal ring (say, a plumbing olive) on the reticule glass then spray it matt black. The ring masks off an area of clear glass to form the pattern. You could experiment with other objects to create crosshairs and other shapes.



Step 5

Use your soldering iron to wire the cell's positive terminal to one switch terminal, then the other switch terminal to the positive (longer) leg of the LED, then the negative LED leg back to the negative cell terminal. Check it works before fitting into the case.



Step 6

Join the case together, including the reticule and mirror mount inside. Add the mirror, aligned so it reflects up through the hole above. Glue the screen and trimmed Fresnel lens in place. We held the side panel with rubber bands, for easy future access.

Take the perfect astrophoto with our step-by-step guide

ASTROPHOTOGRAPHY CAPTURE

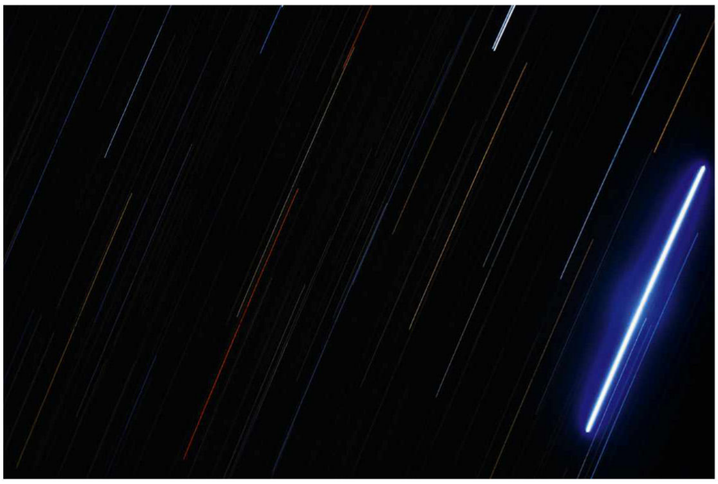
Bring out the colours of stars

From reds to yellows to blues, here's how to reveal the subtle tones of stars in your images

Star colour is often mentioned when we describe the night sky. From the red of Betelgeuse, to the yellow hues of Capella and steely blue-white of Vega, colour descriptors often promise more than the visual or photographic view shows.

There are several reasons for this. For one, when we describe a star as red it may conjure up the image of a bright pure red object shining against the blackness of space, but in reality the colour will appear far more subtle than this, often as a hint of orange. Betelgeuse and Aldebaran are fine examples in the winter sky.

Although the colours may not appear strong visually, what about photographically? Here, although the view is similar, there are things that can be done to reveal colour in a more demonstrable way. There are also things that can be done to completely destroy the depth and quality of star colour, so it pays to be aware of these in order to improve your chances of revealing the stars in all their glory.



▲ Colours can be revealed in star trail captures, like those near bright, electric-blue Vega

Take care with colours

One of the common ways to ruin colour with a DSLR, or equivalent camera, is to opt for a high ISO setting. Although this may give the impression that your camera has enhanced sensitivity, it also reduces the tonal quality of your images, with washed out colours.

When you take a photo of a star, the target will be over-exposed. If you're new to astrophotography and just getting used to taking longer exposures to gather as much light as possible, this may sound like an odd statement. Stars are point sources of light and when you take a long exposure of them the core of the point source over-exposes to white. It's the narrow region between the over-exposed star core and the surrounding space which is properly exposed and contains the star's colour.

Defocusing an image of a star will spread its light over a larger area, and with the correct exposure you can avoid the over-exposed central point which turns to white. A photo of Orion taken with a defocused camera reveals the main star colours.

A popular trick which takes a steady hand control or good compositing skills, is to take a long exposure shot of a constellation and alter the focus of the lens at set intervals during the exposure. This creates the appearance of concentric, or possibly offset, discs of colour overlaid on one another. If you don't think you can pull this off in a single shot without ruining the effect, take separate shots, defocusing a little more each time and combine them in a graphics editor.

Another way to show star colour is to lower camera sensitivity by reducing ISO and shutting down the lens aperture. Placing the camera on a fixed platform and taking a long exposure will then record the correctly exposed colour of the stars in frame, smeared into lines as colourful star trails. This is a really impressive way to show strong star colour.

Opposite are some ideas to help you reveal star colour in your shots. The next time it's clear and dark, give them a go to reveal the true, not so subtle colourful beauty of the heavens.

Pete Lawrence is an expert astro-imager and a presenter on *The Sky at Night*

Equipment: A DLSR or equivalent camera attached to a telescope

Send your images to:
gallery@skyatnightmagazine.com

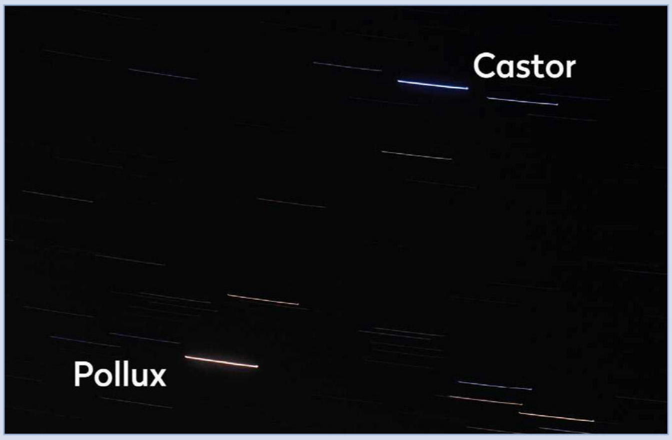
Step by step

STEP 1
The best cameras for star colour are those which offer good manual control, such as DSLRs or MILCs. Most lenses will work, or consider attaching the camera to a telescope. The extra light-gathering power also helps to emphasise colour. You can also use a remote shutter release to avoid camera shake.

STEP 2
If you intend to take longer exposures, consider using a tracking mount to keep the stars sharp. This is true of a camera attached to a scope unless you intend to capture trails. However, this isn't essential for capturing star colour, a fixed tripod being ideal for star trails. A tripod also works well for defocused star images.

STEP 3
A correctly focused star will typically show an over-exposed inner core region which appears pure white. Magnify the star and you should be able to see a ring of pixels around the edge of the white core where the true colour has been recorded. The size of the core and colour fringe are affected by atmospheric seeing.

STEP 4
One way to bring out star colour is to deliberately de-focus the image. This can be done by a small amount to maintain the approximate appearance of stars in the shot. Or you can go for broke and defocus a lot. When you do this, the star's light is spread over a bigger sensor area and over-exposure is less likely.



STEP 5
Starlight can also be spread linearly, into star trails. What you're trying to do here is to avoid allowing a star to over-expose. Setting a low sensitivity (a slow ISO and stopped-down aperture) will help avoid this. The nature of trail captures depends on image scale and your own setup, but try exposures in the 5–15 minutes range.

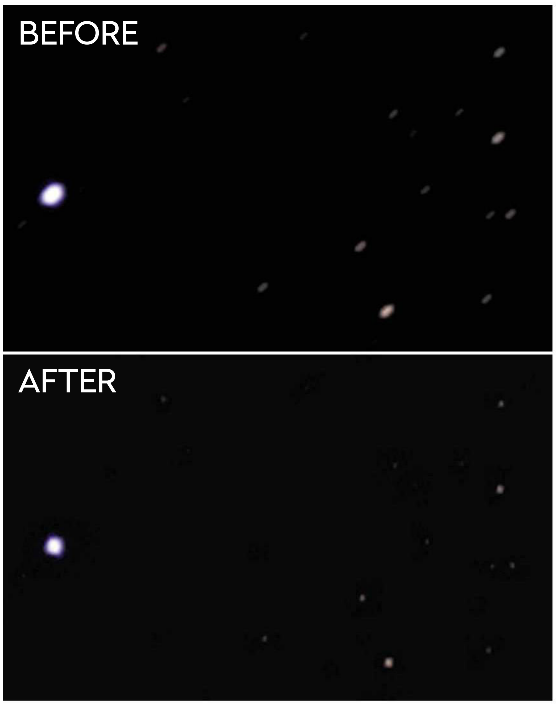
STEP 6
It's easy to submit to the attraction of shorter exposures by increasing ISO, but this is an amplification gain setting that makes a big difference to colour. High values reduce the dynamic range, reducing colour tones and introducing blotched patches of unwanted colour, so lower values, of 200–400, are preferable.

Expert processing tips to enhance your astrophotos

ASTROPHOTOGRAPHY PROCESSING

Reduce star trailing in your astro images

An easy processing tip to remedy stretched and unsharp stars



▲ **Left: Trailed stars in Paul's image of the Coat Hanger Cluster, before and after using blend mode to remove star trailing. Right: The finished image with sharper, rounded star shapes. 21x 60" frames taken with a Canon 50D at ISO 800 and a Sky-Watcher Equinox 80ED**

Astrophotography is an extremely rewarding aspect of astronomy, but as any astro imager will know, conditions often aren't in our favour, which is why we have to take advantage of those rare clear nights whenever they come around. It can be disappointing, then, after capturing those precious images, to discover that they suffer from star trailing.

Slightly trailed stars can be caused by a misbalanced mount or one not quite correctly aligned with the polar axis, making your stars look either stretched or appear as short lines. It would be easy to delete your images and accept that your night's work was in vain, but wait: in some circumstances, you may be able to salvage something from those images by using a simple but effective tip.

In our example we took 21 images of Brocchi's Cluster, also known as the Coat Hanger Cluster, a tiny asterism shaped like a coat hanger in the constellation of Vulpecula. On cursory examination, the stacked image looked good, but when we looked more closely we noticed the stars were slightly trailed.

Star shape enterprise

With our technique it is possible to improve the star shapes, making the overall image look sharp, and enabling you to process it a bit more to bring out detail. Note the following caveats: this technique works best on images that only contain stars taken through a telescope, not widefield constellation images taken with a camera lens suffering from sky rotation trailing. With images of galaxies or nebulae, the effect of this procedure will slightly blur them while improving the stars, and noisy data will create some interesting unwanted artefacts, so it is not an answer for all situations. Indeed, ideal subjects are star clusters without nebulosity such as our Coat Hanger Cluster image. Note also that images with wiggly trails due to windy conditions won't

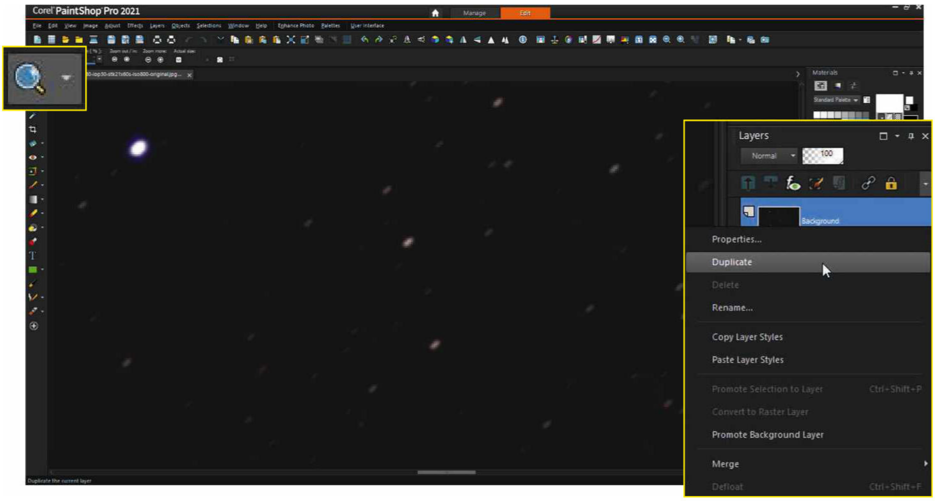
ALL PICTURES: PAUL MONEY

3 QUICK TIPS

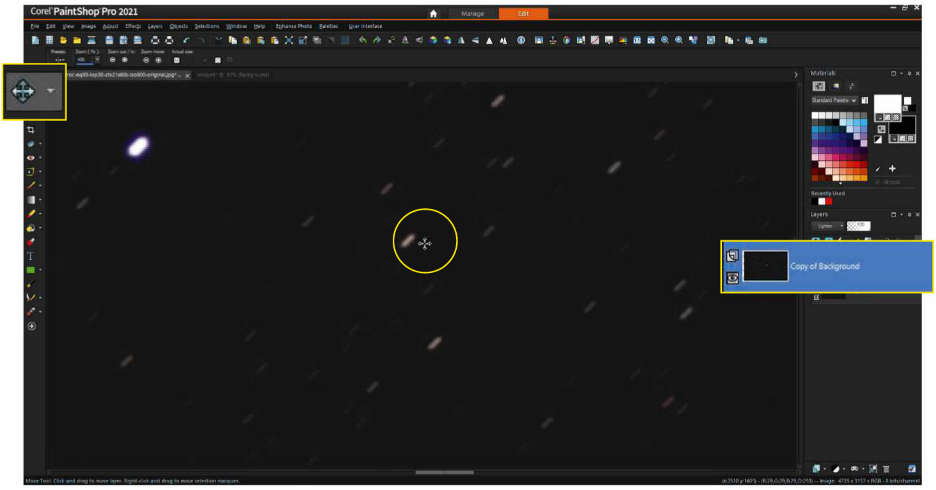
1. To prevent overwriting the original image, always work on a copy.

2. Make small adjustments when moving the top layer, rather than one big adjustment.

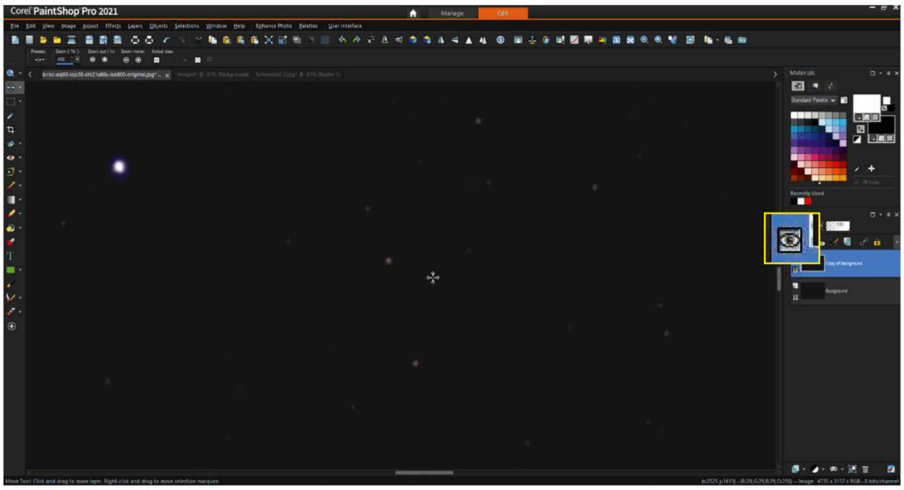
3. Use the visibility toggle for the top layer to check how much you have moved it.



▲ **Screenshot 1: To get from trailed to non-trailed stars, start by making a duplicate of the image on a new layer, then zooming in on some mid-range brightness stars**



▲ **Screenshot 2: Next, lighten the top layer, before very gradually moving it so that both layers' trails overlap. At this stage it looks like you are making the problem worse**



▲ **Screenshot 3: Apply 'Darken' blend mode to the top layer and your stars will now appear sharpened and rounded. Finally, merge the layers to flatten your image**

work as you will end up with some very interesting artwork!

First, if needed, stack your captured images to make a master image, then load this into your favourite image-processing software such as Photoshop, or in our case PaintShop Pro 2021 (see screenshot 1). Right-click on the image shown in the 'Layers' tab on the right, then select 'Duplicate' to create a copy of the image exactly overlaid on the original. It is this layer we will be working with. Now use the magnify tool to zoom into the image. It is better to focus on mid-range brightness stars, as the brightest ones may be a little overblown, whereas mid-range stars have a better shape and it is easier to see their trail.

Next, in the 'Layers' tab select 'Lighten' for the blend mode (screenshot 2). At this stage you won't see any difference; that's normal. Now select the 'Move' tool and the pointer turns into a cross. Holding the left mouse button, carefully drag the copied (top) layer in small increments, keeping an eye on where the trail is moved to. It is here that the lighten blend mode now shows both the upper and base layers' trails. The aim is to nudge the upper layer until the lower end of its trail overlaps the top end of the trail of the base layer. It will look like all you have done is double the length of the trail, but fear not!

You can click the 'eye' icon on the topmost layer, which is the visibility toggle, so you can swap back and forth between seeing both layers or just the original layer, to gauge just how much you have moved the top layer by. Once you are happy with the right amount of overlapping on the trails, you can select 'Darken' blend mode for the top layer and voilà: you now have nice round stars instead of trails (screenshot 3).

Right-click on the topmost layer tab and select 'Merge all' to flatten the image. Zoom back out to see the full image with sharp stars. You may find you can further enhance the final image with histogram adjustments and a little extra saturation. In our final image (see opposite), this even brought out the small open cluster NGC 6802 at the bottom left of the Coat Hanger Cluster.

Paul Money is an astronomy writer and broadcaster, and the reviews editor of *BBC Sky at Night Magazine*

Your best photos submitted to the magazine this month

ASTROPHOTOGRAPHY GALLERY

More **ONLINE**
A gallery containing these and more of your images

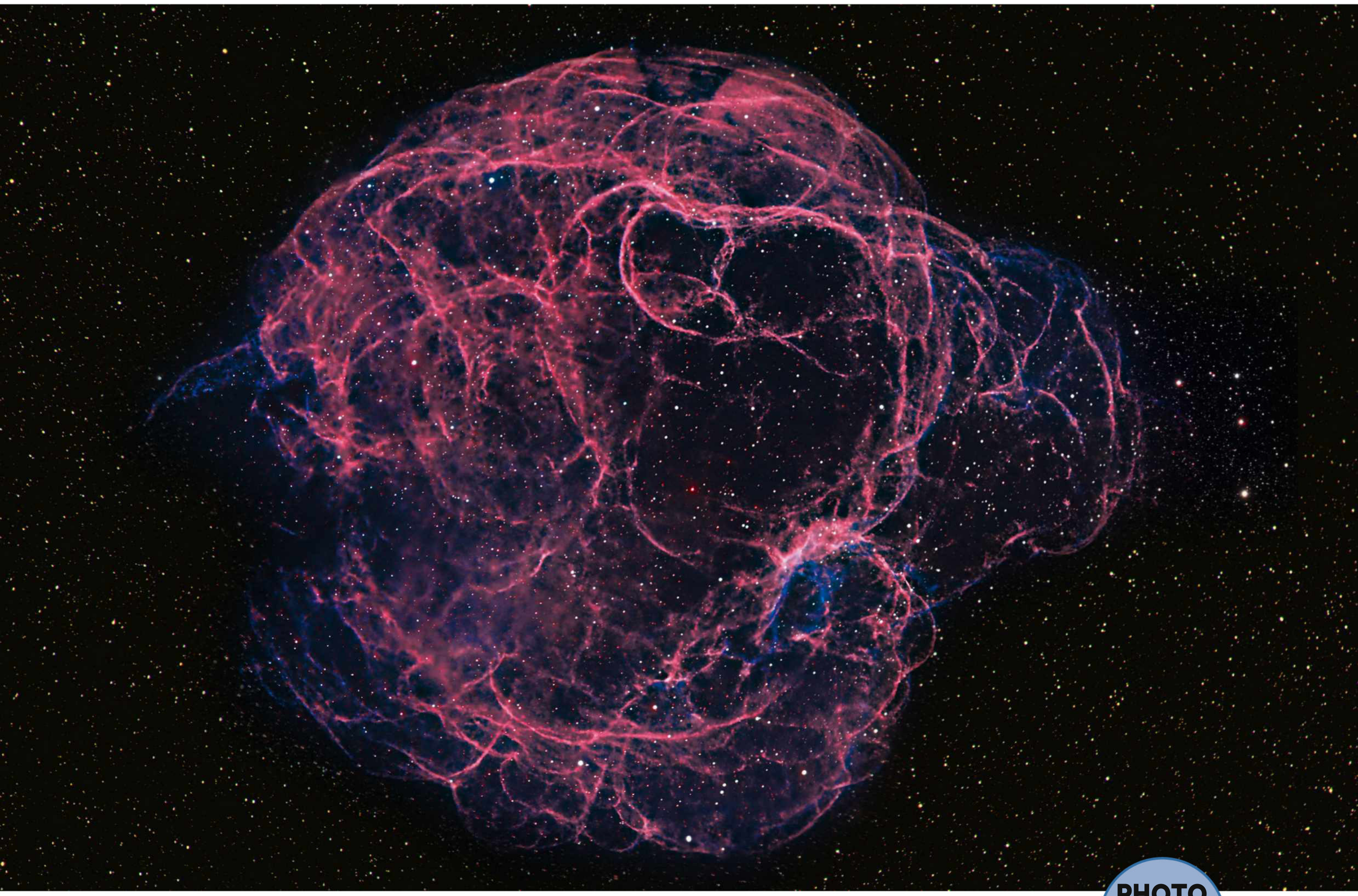


PHOTO OF THE MONTH

△ The Spaghetti Nebula

Michael P Caligiuri, Anza Borrego Desert, California, 25–26 November 2022

Michael says: "Sh2-240 is a supernova remnant located 3,000 lightyears away. It's believed to be the remnant of a star that exploded 40,000 years ago. What sets this image apart from my prior attempts is that I was able to acquire sufficient OIII (oxygen). While dim, there is OIII throughout the filaments, a feature often missed in HaRGB images."

Equipment: ZWO ASI294 camera, Samyang 135mm f/1.8 lens at f/4, Astro-Physics AP1100 equatorial mount
Exposure: 13h 45'
Software: MaxIm DL, CCD Stack, Photoshop

Michael's top tips: "Shooting with a 135mm camera lens allowed me to capture a full 3°-span of the sky, and to frame it against a starry background. With that original field of view, cropping and framing to taste becomes easy. I've been adding RGB data to my narrowband workflow. Once the bi- or tri-colour narrowband layers are blended, I remove the narrowband stars using StarXTerminator and replace them with a more natural-looking RGB star layer. This blend of narrowband nebulosity against RGB stars can be stunning."

◁ Lunar occultation of Mars

Chris Kotsiopoulos, Reading, 8 December 2022

Chris says: "It's quite an experience seeing Mars disappear behind the Moon and emerge after an hour. I was freezing cold with frost on my equipment, but it was worth it! The processing was a challenge, as I'd never shot an occultation with a CMOS camera."

Equipment: ZWO ASI120MM Mini camera, Celestron C90 Maksutov, Sky-Watcher Star Adventurer Pro **Exposure:** 40" video: 1,000 still images (best 25 per cent stacked) **Software:** SharpCap, AutoStakkert!, Photoshop

The Double Cluster in Perseus ▷

Shawn Nielson, Kitchener, Ontario, Canada, 14 November 2022

Shawn says: "I've noticed that clusters don't seem to be imaged as much as more visually striking nebulae. I particularly like this pair of open clusters in Perseus with their pretty coloured stars, as they're not too tightly packed together and not too far apart. The Double Cluster has just the right appearance. I used LRGB filters in my filter wheel for this image."

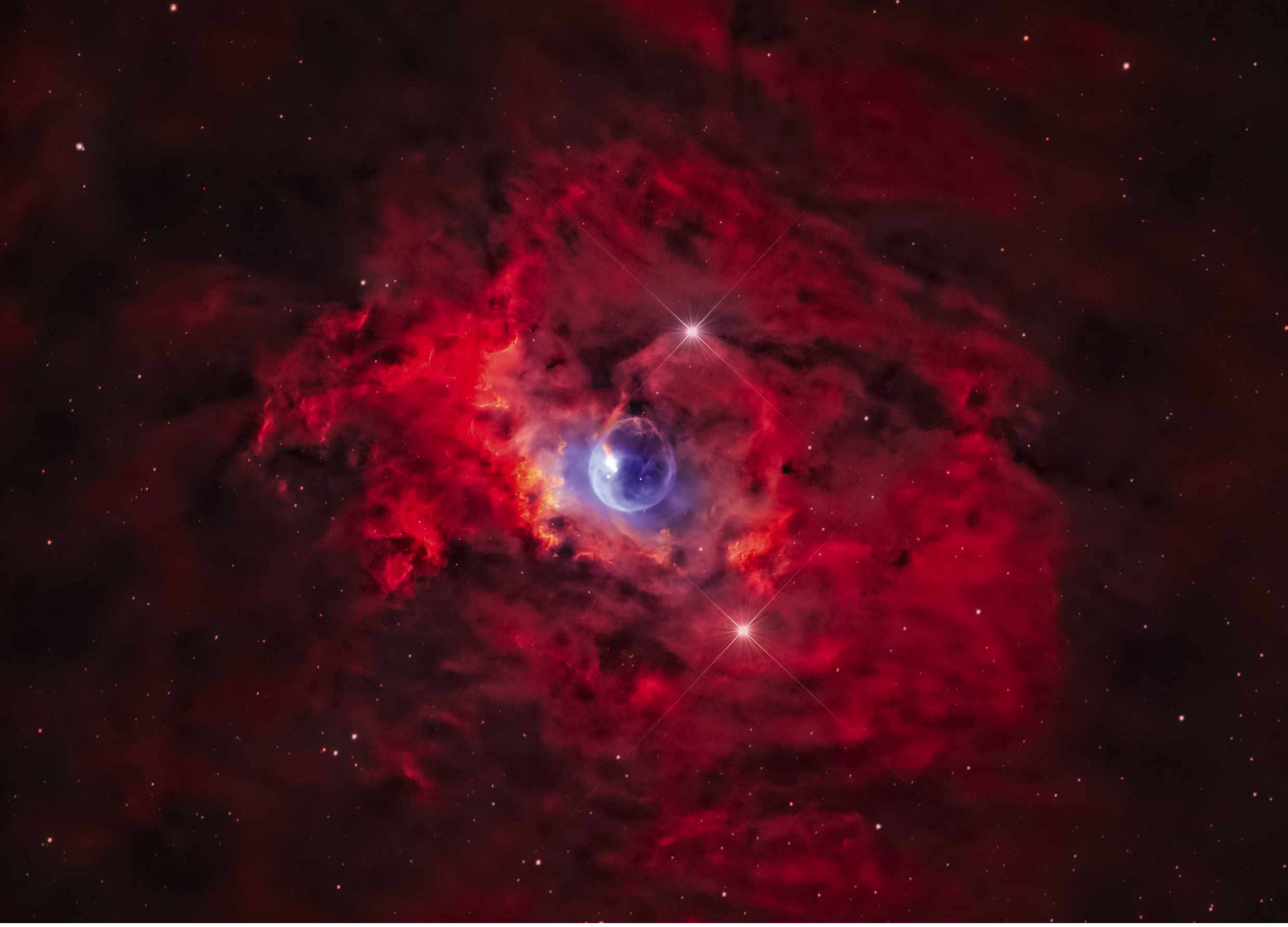
Equipment: QHY268M camera, Starfield Optics 8-inch Newtonian reflector, Sky-Watcher EQ6 mount **Exposure:** 3.5h **Software:** NINA, PixInsight

◁ Solar prominence

Anton Matthews, Bristol, 5 December 2022

Anton says: "Recently I have become fascinated by solar astronomy, and the awe-inspiring chromosphere. I hope to upgrade my setup with a dual mount so I can photograph white light and Ha (hydrogen alpha) simultaneously. I caught this solar prominence ejecting from the disc at about 9:20am."

Equipment: ZWO ASI224MC camera, Coronado Personal Solar Telescope, Sky-Watcher Solar Quest mount on Horizon photographic tripod **Exposure:** 500 frames **Software:** PIPP, AutoStakkert!, GIMP



△ The Bubble Nebula

Carl Gough, Littlehampton, West Sussex, October–November 2022, with some data from 2021

Carl says: "I call this the 'bubbling rose' due to the surrounding dust looking similar to a red rose, with a bubble at the centre. It's actually the Bubble Nebula, or NGC 7635, and it resides approximately 8,000 lightyears away in Cassiopeia. The data was mostly acquired in late 2022, but I added some from 2021 to pull out some extra detail."

Equipment: ZWO ASI1600MM camera, Orion 8-inch f/8 Ritchey-Chrétien astrograph reflector, EQ6 mount
Exposure: 118x 600" Ha, 63x 600" OIII, 58x 600" SII
Software: PixInsight, Lightroom, Photoshop

◁ Mars occultation trails

Tomáš Slovinský, Kosice, Slovakia, 8 December 2022

Tomáš says: "Shooting was quite tricky, especially because of the weather. But a few minutes before the event, clouds above my backyard disappeared, only to reappear a few minutes after it had ended."

Equipment: Canon EOS R6, TS-Optics 1,000mm Newtonian, Sky-Watcher Star Adventurer, Leofoto Summit LM-405C tripod **Exposure:** 1/60", ISO 100–1200 **Software:** Photoshop

◁ The Andromeda Galaxy

Davy Viaene, remotely via the E-EyE Observatory, Spain, 3 & 8 November 2022

Davy says: "In autumn, the Andromeda Galaxy, M31, reaches high altitudes and is visible all night, which makes it ideal to aim at. The combination of telescope and camera makes it possible to frame the galaxy in one shot. In post-processing, I slightly changed the natural colours of M31's outer parts, making them more blue. The technical challenge is always fun."

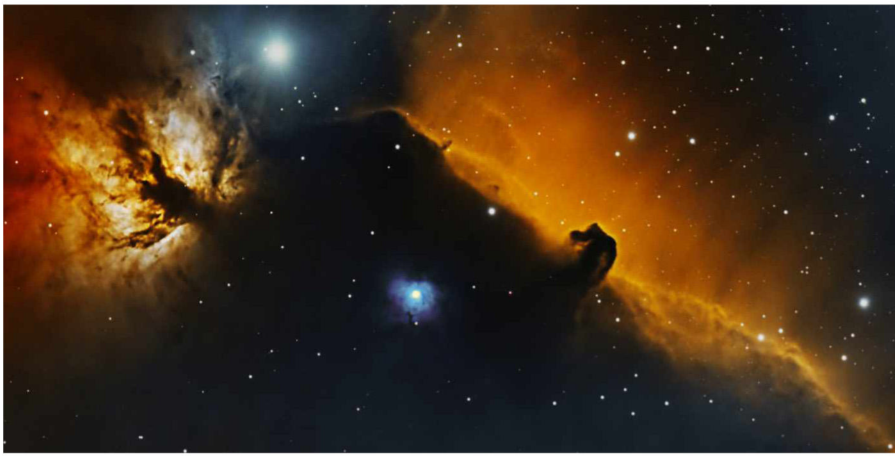
Equipment: ZWO ASI6200MC Pro camera, Takahashi FSQ106ED III refractor, Paramount MyT robotic mount **Exposure:** 4.5h **Software:** TSX, CCD Commander, PixInsight

The Horsehead Nebula ▷

Pat Devine, Edinburgh, 20 and 25 November 2022

Pat says: "I took up astrophotography in 2020 and joined the Edinburgh Astronomical Society, taking advantage of their online resources. I have seen pictures of the iconic Horsehead Nebula since I was a child, so it was one of the first targets I wanted to try to capture when I started imaging. I used narrowband filters to deal with the light pollution."

Equipment: ZWO ASI183MC Pro camera, Celestron 8-inch Rowe-Ackermann astrograph reflector, Sky-Watcher HEQ5 Pro mount **Exposure:** 3.4h **Software:** PixInsight, Photoshop



◁ The Dumbbell Nebula

Francis Bozon (left) and Jean-Luc Gangloff from Team ARO, remotely via Alentejo Remote Observatory, Portugal, 4 August–28 September 2022

Francis says: "The Dumbbell Nebula is a planetary nebula located in the constellation of Vulpecula, about 1,227 lightyears away. It was discovered by Charles Messier in 1764 and is numbered 27 in his catalogue. Looking at M27 is like looking at the end of our own Solar System in five billion years' time."

Equipment: Moravian G3-16200 camera, Astrosib RC 400 Ritchey-Chrétien reflector, ASA DDM85 direct-drive mount **Exposure:** 52h **Software:** PixInsight, Photoshop

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Whether you're a seasoned astrophotographer or a beginner just starting out, we'd love to see your images. Send them to us at www.skyatnightmagazine.com/send-us-your-astrophotos

hama

We've teamed up with Modern Astronomy to offer the winner of next month's Gallery a Hama lens pen, designed for quick and easy cleaning of telescope optics, eyepieces and camera lenses. It features a retractable brush and non-liquid cleaning element. www.modernastronomy.com • 020 8763 9953

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A six-lens refractor with a built-in field flattener, designed for APS-C cameras 86

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HOW WE RATE

Each product we review is rated for performance in five categories. Here's what the ratings mean:

★★★★★ Outstanding ★★★★★ Very good
★★★★★ Good ★★★★★ Average ★★★★★ Poor/avoid

Sharpstar Z4 sextuplet apo astrograph

Designed for APS-C cameras, this six-lens scope delivers on its flat-field promises

WORDS: CHARLOTTE DANIELS

VITAL STATS

- **Price** £2,259
- **Optics** Air-spaced apo sextuplet
- **Aperture** 100mm
- **Focal length** 550mm, f/5.5
- **Focuser** 3.4-inch dual-speed rack and pinion; 1:10 ratio fine adjustment knob
- **Extras** Dovetail bar, tube rings, adaptors, carry case, handle, retractable dew shield
- **Weight** 4.3kg
- **Supplier** First Light Optics
- **Tel** 01392 791000
- **www.**firstlightoptics.com

The Sharpstar Z4 is the latest offering from the Sharpstar family of astrograph refractors geared specially towards astrophotography. With a 100mm front element, it is second in size only to the Sharpstar 140PH. However, while its sibling boasts greater aperture and focal length, the Z4 arguably packs a significant punch with a six-element optical system. By virtue of this sextuplet design, the Z4 is developed to go above and beyond conventional doublet and triplet apochromatic refractors, by further minimising image distortions including vignette, field curvature and colour fringing.

Upon opening the box, we were greeted by a smart and solid locking case. Its unique twist-and-lock system was reassuring – we had no doubt that the locks would hold securely, over and above the clamps seen on other cases. The excellent build design of the case carried over to the telescope inside, where the muted matte silver and grey colours gave a sleek and sharp appearance that we found impressive. It's nice to see something a little different to the standard white tubes.

Heavy weather

Winter skies proved damp and temperamental, but we were keen to put this uniquely designed astrograph through its paces. Mounting the Z4 was easy enough, the carrying handle enabling us to lift it into position, but we did note that the extra glass incorporated into the sextuplet design added considerable weight. At 4.3kg, it pushes close to the limits of what we would deem a portable or a beginner's telescope, especially if adding a large camera and guide accessories. While we were able to achieve balance relatively easily for our imaging setup, we did wonder whether the Z4 would benefit from a slightly longer dovetail for those with heavier imaging ▶

ALL PHOTOS: @THESHED/PHOTOSTUDIO

SCALE

Integrated carrying handle

Attached to the tube ring, the robust carrying handle is specially machined to allow the fitting of a guidescope bracket, an essential accessory for many astrophotographers. It also makes mounting and balancing the telescope easy and secure, as it reduces the risk of dropping the telescope while transporting or adjusting its position.

Vixen-style dovetail and built-in tube ring

The 300mm Vixen-style dovetail plate is smartly colour-coordinated and designed to be easily attached to standard equatorial mounts. The accompanying clamshell-style tube ring holds the Z4 securely with no flexure, and its position along the dovetail plate is easily adjustable to ensure the setup can be properly balanced.

Dual-speed focuser

The large 3.4-inch focuser reduces vignetting and comes with a 1:10 fine adjustment knob, allowing the user greater control and accuracy over the focusing process. Meanwhile the 360° built-in rotator, positioned just behind, allows complete rotation of the focuser barrel, ensuring no loss of focus while adjusting camera angle or orientation.

FIRST LIGHT

Six-lens design

As a sextuplet astrograph, the Sharpstar Z4 comprises three lenses at the front and three at the back of the optical tube assembly. Two of these are extra low dispersion (ED) glass, one positioned at either end of the tube. These are designed to dramatically reduce the effects of chromatic aberration, including star halos. The Z4's optical layout promises and delivers a flat field across a 36mm image circle – equivalent to the APS-C (crop sensor) DSLR or astro cameras used by many astrophotographers. This means that vignette is minimised when coupled with APS-C cameras. Moreover, the sextuplet's built-in flattener removes the expense and complexity of purchasing and correctly spacing a separate flattener.

With an aperture of 100mm, f-ratio of 5.5 and corresponding 550mm focal length, the Z4 also has an excellent profile for deep-sky widefield imaging. This astrograph provides the perfect field of view for many popular nebulae and star clusters, and notable improvements on edge-to-edge image quality for photographers upgrading from budget or intermediate telescopes.

Retractable dew shield

Dew is the bane of astrophotographers' lives, and a dew shield is essential to ensuring optics stay free from the effects of moisture. The fully retractable dew shield ensures the system is compact, making the refractor only 482mm when pushed back, and reduces the risk of damaging the telescope while moving it.

Adaptors

The Sharpstar Z4 comes with a suite of adaptors to attach all types of cameras and accessories for DSLRs and CMOS or CCD cameras. They include M86, M68, M54 and M48 adaptor types. The M48 adaptor is fitted with an internal thread designed to accommodate two-inch filters.

@THESHED/PHOTOSTUDIO X 3, CHARLOTTE DANIELS X 2

▲ **Even a short exposure delivered wonderfully flat field views of the Sadr region. Sharpstar Z4 paired with Canon EOS 70D, ISO 3200, 225x 20"**

▶ equipment. Nevertheless, we found preparing the Z4 for clear skies a breeze. Because of the short window of opportunity the weather gave us, we elected to use a DSLR for some short-exposure photography.

Attaching the camera was relatively easy thanks to the adaptors provided, although we needed our own M48 to T2 adaptor to attach the DSLR via a T-ring. Sharpstar recommends using a crop sensor (APS-C) camera on the Z4, and so we popped our Canon 70D on first. The rack and pinion focuser felt exceptionally well-made and allowed complete control over the focusing process. We were confident that the focus would hold throughout the imaging session and slewed over to the Sadr region in Cygnus.

Flat and clean

Some initial test frames confirmed a wonderfully flat field of view with no observable star curvature or halos, despite the prominent star Gamma Cygni. We fired off an hour's worth of frames on the bright Butterfly Nebula (IC 1318) before a short hop over to the Tadpoles (IC 410), the Red Spider (NGC 6537) and the Fly (NGC 1931) nebulae. After capturing another hour of data, we decided to pop our full-frame Canon 6D DSLR on for a couple of test frames. We saw that, unsurprisingly, the corners were cut off and therefore there would be vignetting if using the Z4 with full-frame cameras.

Heading inside, we were curious to see how the field of view looked in post-processing. Stretching the data confirmed a flat field with pin-sharp stars edge to edge. We could not detect any fringing around the stars either, which further helped our processing as it made balancing and controlling our colours more straightforward. Despite the relatively short exposure times, we were left with images from which we were able to get optimal results as we weren't inhibited by bloated stars or uneven background gradients.

Price-wise, the Sharpstar Z4 is positioned towards established astrophotographers rather than beginners, though it is certainly user-friendly enough to be suitable for any and all imagers, as long as they use APS-C DSLR cameras. Ultimately, the Z4 proved a superbly-made and smart astrograph that contributed to beautifully clean images. It's a sophisticated optical system we would certainly wish to use again and again.

▲ **Pin-sharp stars in the Tadpoles (IC 410) impressed. Same setup, ISO 3200, 180x 30"**

VERDICT

Build & design	★★★★☆
Ease of use	★★★★☆
Features	★★★★☆
Go-To/tracking accuracy	★★★★☆
Optics	★★★★☆
OVERALL	★★★★☆

KIT TO ADD

1. ZWO electronic automatic focuser

2. Lynx Astro 40cm dew heater strap for four-inch telescopes

3. Antlia ALP-T dual band 5nm filter

Sky-Watcher Heritage 150P Virtuoso GTi Wi-Fi Dobsonian

This crowd-pleaser offers simple setup, sharp views and smartphone control

WORDS: STEVE RICHARDS

VITAL STATS

- **Price** £419
- **Optics** 150mm (6-inch) Newtonian, parabolic primary mirror
- **Focal length** 750mm, f/5
- **Mount** Tabletop Dobsonian
- **Extras** Red dot finder, 25mm and 10mm 1.25-inch eyepieces, SynScan app, dovetail bar, collimation cap, manual
- **Weight** 8.8kg
- **Supplier:** Optical Vision Ltd
- **Email:** info@opticalvision.co.uk
- **www.**opticalvision.co.uk

The Sky-Watcher Heritage 150P Virtuoso GTi Wi-Fi Dobsonian telescope is an enhanced Go-To version of the popular Sky-Watcher Heritage-150P FlexTube Dobsonian.

The tabletop, single-fork Dobsonian design has additional pods installed that contain the control electronics and drive motors for the altitude and azimuth axes, allowing a huge range of celestial objects to be located, tracked and observed using Go-To technology.

The mount arrived beautifully packaged with a full-colour-printed inner box to enhance its presentation. The mount has a smart black and white appearance, while the telescope has a metallic black gloss finish with a contrasting green dovetail bar. The optical tube incorporates Sky-Watcher's tried and tested FlexTube construction, which allows the telescope to contract in length for easy storage and transport. This feature places the telescope firmly in the portable category, so it could easily be taken to a dark-sky location. The mount can be powered internally by eight AA batteries or by an external 12V power tank.

Assembly was ridiculously quick and only required the loosening of the dovetail bar clamp, sliding the telescope upwards to allow the removal of some safety packaging, extending the FlexTube stays and sliding the red dot finder onto its shoe. Collimating the telescope with the supplied collimation cap was very straightforward.

Phone home

The control panel on the mount incorporates a port for a conventional Sky-Watcher SynScan wired hand controller, but the hand controller is not included. Instead, the innovative Go-To system has built in Wi-Fi, allowing connection to a smartphone ▶

Tabletop design

Sky-Watcher's tabletop Dobsonian designs breaks the mould, bringing the solid and reliable Dobsonian mounting method within the reach of those desiring a smaller, more manageable telescope.

The tabletop design reduces the size and weight of the mount although it does, of course, assume that a suitable table is also available. However, if you don't want to use it on a table, the mount also incorporates a standard 3/8-inch tripod bush in its base so the mount and telescope can be installed on a suitable tripod instead.

The conversion to Go-To adds the icing on the cake and the Virtuoso's Go-To system, using a free app compatible with the most popular smartphones, brings the Dobsonian concept right up to date. The ease of locating objects using this intuitive feature made it an absolute pleasure to use, and its quiet operation meant that it was also very neighbour-friendly. The SynScan app uses your smartphone's GPS to collect your location and time, calculating the correct pointing angles following a simple alignment process at the start of each observing session.

@THESHED/PHOTOSTUDIO X 3, STEVE RICHARDS

SCALE

Red dot finder

The red dot finder provides an intuitive method for locating bright objects by projecting an apparent red dot on the night sky. Once aligned with the telescope itself, it's simply a matter of adjusting where the telescope points until a bright object and the dot are aligned with one another.

FlexTube design

The telescope uses the FlexTube design, which is deceptively simple but very effective. For storage and transport, the front of the telescope slides down on two support struts onto the main body, and a cap can be fitted to protect the primary and secondary mirrors from dust and other damage.

Optics

The telescope has a 150mm-aperture parabolic primary mirror with a focal length of 750mm, and its good light grasp makes it ideal for a wide range of observations. The mirror is exactly the same well-figured design as the one supplied with Sky-Watcher's well-established and popular 150P Newtonian telescope.

FIRST LIGHT

KIT TO ADD
1. 1.75-inch stainless steel tripod
2. SynScan handset and cable
3. 17Ah 12V power tank

▶ running the free SynScan App (available from the App Store for iOS or Google Play for Android). This comprehensive app gives access to all the mount's setup and control features using an intuitive graphical user interface. Using the iOS Pro version on our iPhone SE 2020, we enjoyed flawless operation throughout the review period, although the lack of any tactile feel to the virtual direction keys made it easy for our fingers to slip off the control area.

Targets acquired

The SynScan app stores various catalogues including NGC, IC, Messier, Caldwell (Patrick Moore), Named Deep Sky Objects, Named Stars, Double Stars and Solar System objects (the planets, Sun, Moon and comets), giving Go-To access to over 10,000 targets. In addition to controlling the Go-To functions, the app provides a useful database of information about each object in the catalogues, including visibility times, to help you plan observing sessions in advance. There is also a rather handy 'tonight's best' list for if you haven't already planned your session.

Although the mount's main operation is via Go-To, it also utilises Sky-Watcher's 'Freedom Find' function. This feature allows you to unlock the azimuth and altitude clutches then rotate and tilt the telescope by hand to search for celestial objects manually, without the app losing track of where the telescope is pointing. This useful facility makes use of two auxiliary encoders that update the app on where the mount is currently pointing, so that when the clutches are re-engaged, the telescope doesn't have to be re-aligned to continue Go-To operation.

The planets Jupiter and Mars were well-placed during the review period, with Mars's red disc, and Jupiter's bands and gorgeous pin-prick moons clearly visible through the eyepiece. We also enjoyed excellent views of the Hyades and Pleiades star clusters, the Andromeda Galaxy, Dumbbell, Ring and Orion nebulae, double stars Albireo and the Double Double, and some wonderful detail on the Moon. After each slew, the Go-To system successfully placed each object well within the 25mm eyepiece's field of view.

The Sky-Watcher Heritage 150P Virtuoso GTi was a lot of fun to use, and beginners and youngsters would particularly appreciate its presentation, compact size, easy-to-set-up design and its control via a smartphone. Being able to manually locate objects without losing the electronic alignment is a real bonus, and the 150mm aperture allows observations of a wide range of objects.

Helical focuser

Unusually for a telescope of this size the focuser is a helical design, which is compact and simple. It works by screwing the whole eyepiece holder in and out of the focus tube to achieve focus. However, we did note that it was a little coarse in operation.

Eyepieces

The telescope comes with a 25mm and a 10mm eyepiece, which give magnifications of 30x and 75x respectively. Both eyepieces have convenient rubber fold-down eyecups for comfort when observing. Although the 25mm eyepiece was perfectly adequate and gave good views, especially for a beginner, the 10mm version was less inspiring.

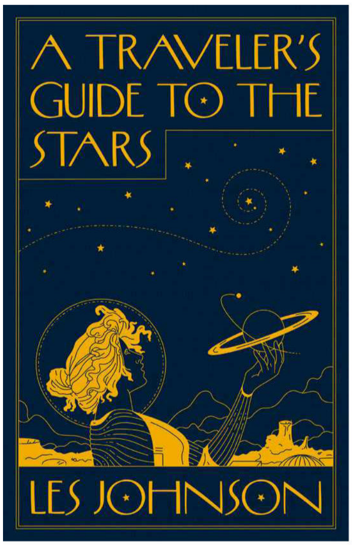
▲ The Moon, captured through the Virtuoso's eyepiece using an iPhone

VERDICT

Build & design	★★★★☆
Ease of use	★★★★☆
Features	★★★★☆
Go-To/tracking accuracy	★★★★☆
Optics	★★★★☆
OVERALL	★★★★☆

@THESHED/PHOTOSTUDIO X 2, STEVE RICHARDS

BOOKS



A Traveler's Guide To The Stars

Les Johnson
Princeton University Press
£22 ● HB

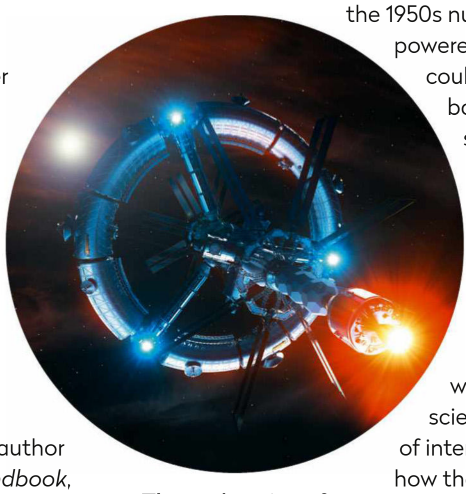
Penned by the former head of NASA's turn-of-the-century Interstellar Propulsion Research Project, this is a concise book on a big topic: could (and should) we travel to another star? The book is dedicated to Gregory Matloff, co-author of *The Starflight Handbook*, the 1991 bible of interstellar travel. So do we really need another? Have there really been that many developments within just three decades?

The answer, writes Johnson, is yes. For a start, it was only during the 1990s that the first exoplanets were discovered, so starships finally have destinations to aim for, even if Earth-like exoplanets remain elusive. NASA and other institutions are studying probes to explore the interstellar medium, which might eventually arrive at the focus of our Sun's own gravity lens, about 550 AU away. Our parent star's bending of spacetime would make far-distant celestial objects – including rocky exoplanets – resolve into view as if right beside our spacecraft.

Technology has moved on too, says Johnson. The proliferation of shoebox-sized 'CubeSats' in Earth orbit shows how tiny 'chipsats' could do worthwhile work, while staying small enough to be economically accelerated to a reasonable fraction of lightspeed. Novel materials like atom-thick, stronger-than-steel graphene might make suitable sails for laser propulsion. Maintaining human-carrying 'worldships' across multiple generations is becoming more feasible.

This book is no science paper, but sets out its stall in clear prose, supported by elegant illustrations. Will we ever make it to another star? Johnson argues it is already possible on a brute force basis: the 1950s nuclear-bomb-powered Orion concept could accelerate a battleship-sized spacecraft to a tenth of lightspeed, but at the cost of potentially contaminating our own world.

The end result is a satisfying read, which also discusses science fiction examples of interstellar travel. Noting how the majority of his NASA colleagues were motivated to get into the space field by *Star Trek*, Johnson argues that sci-fi needs to be considered: "Going to the stars will not happen unless people have a vision to make it happen." ★★★★☆



The exploration of exoplanets will inspire future space missions

3DSCULPTOR/ISTOCK/GETTY IMAGES

***Sean Blair** is senior editor for European Space Agency Technology and Navigation*

Interview with the author
Les Johnson

Is interstellar travel currently possible?

Technically, yes. The Voyager spacecraft, if pointed in the right direction, could arrive at another star system in about 70,000 years, but they would be dead and non-functional. Within the known laws of physics, we might be able to get spacecraft to accelerate much faster and get to another star in a few hundred years, but there's a difference between physics and engineering. Today, we don't have the engineering skills to build spacecraft to travel those distances that fast.

How much data could we get?

Unless you can slow down, you're going to fly through a star system in days. Data would be quickly received and transmitted back, then you're back out in deep space. We need to launch many probes cheaply to different destinations, so our descendants don't just get data from one location. Instead, they'll get it from a host of exoplanets.

Where should we go?

The nearest star and the planets around it are an obvious choice, but ultimately we want to survey the 100 nearest star systems with planets. If we're sending humans, we want to send them somewhere there's hope for survival. But who knows what our great grandchildren will look like, how disease resistant they'll be and how long they'll live. What will environmental support systems look like in 150 years? Maybe instead of modifying an environment, our descendants will modify themselves for the environment. We shouldn't underestimate what changes might happen over several hundred years.

***Les Johnson** is a NASA space propulsion technologist*

Space Race 2.0

Brad Bergan
Quarto
£28 ● HB

Privately funded space travel, a long-time staple of science fiction, has become a reality of the 21st century at a phenomenal pace, compared to previous state-funded approaches. *Space Race 2.0* tells the story of this commercial battle to turn dreams inspired by Apollo into profitable business models.

It begins with a brief biography of the three main players – Elon Musk, Richard Branson and Jeff Bezos – including a discussion of the conditions that have allowed them to become so wealthy. The main body of the book chronicles the often explosive search for reusable launch systems that can open up space for both people and payloads. It covers flights up until early 2022, including William Shatner becoming the oldest astronaut to date. The final chapters deal with China's recent accelerated space programme and a look to the future.

Each chapter contains a wealth of large colour photographs of the hardware, along with some beautiful artists' impressions of future goals. The author also looks at some of the wider implications of this new industry, for example, on the environment both on Earth and in orbit.

There aren't a lot of technical details about the vehicles themselves, however, as this book gives a more journalistic account of the flights and some of the resulting social media or legal squabbles.

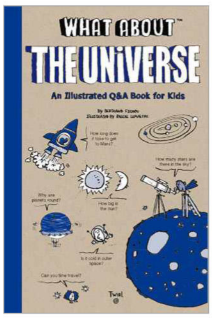
Overall, *Space Race 2.0* gives a wonderful snapshot of commercial space flight as it stands today. As well as being an interesting read, it will be something to look back on as the race continues. ★★★★☆

***Mark Bowyer** is a science writer specialising in crewed spaceflight*

What About The Universe?

GREAT FOR KIDS

Bertrand Fichou
Twirl
£12.99 ● HB



If you're looking for a great and fun astronomy present for your insatiably curious nine-year-old niece or nephew, stop looking and buy this book. But before you give it away: make sure to enjoy it yourself. At the very least, it will provide you with an entertaining refresher course of astronomy basics.

There are plenty of children's books about the Universe, but in many cases they are disappointingly superficial when it comes to factual content. This is a missed opportunity, young kids are one of the most knowledge-hungry audiences. Indeed, they revel in surprising facts, crazy concepts, weird ideas and unimaginable numbers. Little wonder that almost all children are excited about astronomy and space.

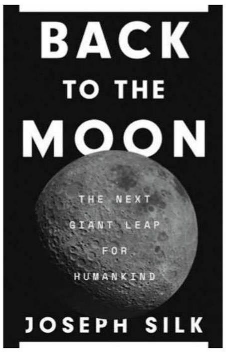
Author Bertrand Fichou doesn't shy away from difficult topics. In fact, the first two spreads of his book discuss the expansion of the Universe and the Big Bang. The 40 or so mini-chapters in the book all have a question as a title, like 'Why don't people on the other side of Earth fall into space?', 'Can you time travel?' and 'How do planets and stars get their names?'. The many subjects are all well-chosen and clearly answered in a straightforward and easy-to-grasp style.

The real value of the book is in the comical-yet-informative drawings by Pascal Lemaître (a distant relative of Georges Lemaître of Big Bang theory fame). Loaded with funny characters and humorous details, these illustrations will grab the attention of young inquisitive readers, and help them grasp the wonders of the cosmos. ★★★★★

***Govert Schilling** is an astronomy writer and author of Ripples In Spacetime*

Back To The Moon

Joseph Silk
Princeton University Press
£25 ● HB



The Moon is widely recognised as a valuable resource, not only in terms of exploitation but also in aiding our understanding of our place in the Universe. Ultimately, it helps us to answer a question we have been pondering for thousands of years: "are we alone?". With the recent successful launch of Artemis I in November 2022, our quest to establish a human presence on the Moon is growing ever closer. A new Space Race has begun.

Back to the Moon explores the fundamental topics surrounding this new era of discovery, including the construction of bases on the lunar surface, mining and – perhaps most pertinently – space law. Author and astrophysicist Joseph Silk does not beat around the bush, offering us the facts in a no-nonsense way that the reader will find thrilling, fascinating and sometimes even concerning.

Using examples reminiscent of an Arthur C Clarke story, Silk will have you pondering the future of Moon exploration and what that means for all of us. He delves into the problems and threats that we face here on Earth and how space can be used to our advantage. Conveying the challenges and the exciting possibilities that lie ahead, including the construction of gigantic telescopes on the far side of the lunar disc, *Back to the Moon* has an 'all-rounder' appeal. While the book is suitable for those starting out in their quest to learn and understand the possibilities of lunar exploration, it will also appeal to those more experienced readers requiring an up-to-date account.

Perfect for readers at any level, *Back to the Moon* will satiate the most curious of minds. ★★★★☆

***Katrin Raynor** is a science writer and a fellow of the Royal Astronomical Society*

Ezzy Pearson rounds up the latest astronomical accessories

GEAR

1 Astro Essentials CLS filter

Price from £38 • **Supplier** First Light Optics • **www.firstlightoptics.com**

Cut through the urban glow with this City Light Suppression (CLS) filter, which transmits several nebula emission lines while cutting out those from light pollutants. Pair it up with a CCD, CMOS or DSLR camera to enhance contrast and detail.

2 Antlia Imaging 1.25-inch CaK Herschel wedge

Price £370 • **Supplier** 365 Astronomy • **www.365astronomy.com**

ADVANCED Herschel wedges cut down transmitted light, allowing you to safely observe the Sun with a refractor. This wedge has a 3nm prism focused on the 393.3nm Calcium II K line, allowing you to see details in the chromosphere.

3 Space Exploration NASA AstroPlanetarium

Price £99.99 • **Supplier** Telescope House • **www.telescopehouse.com**

Transform your home into a planetarium with this projector. It comes with two slide discs – one with 61 labelled constellations, another showing 8,000 stars – which it displays onto your walls with bright LEDs.

4 Result Microfleece jacket

Price £17.05 • **Supplier** Result • **https://shop.resultclothing.com**

Staying warm needn't cost the Earth, with this fleece jacket made from recycled plastic bottles. It can be worn on its own when it's mild or layered under a heavier coat in colder weather. It comes with a high neck and elasticated wrists to keep cold air at bay.

5 Sky-Watcher CQ350 polarscope

Price £89 • **Supplier** Harrison Telescopes • **www.harrisontelescopes.co.uk**

Polar-aligning your equatorial mount ensures you stay on target for a night's astrophotography. This polarscope for AZ-EQ5 mounts makes the process fast so you can spend more time observing the sky.

6 William Optics Dura Bright 2-inch diagonal

Price £155 • **Supplier** The Widescreen Centre • **www.widescreen-centre.co.uk**

The mirror of this new diagonal has 99 per cent reflectivity, so you won't sacrifice much light to have your eyepiece at a more comfortable angle.

Melissa Brobby interviews Dr John Ilee

Q&A WITH A PLANETARY SCIENTIST

The materials that form the building blocks of life on Earth have been found in distant planet-forming discs that are the same size as the Solar System

You have identified organic molecules in protoplanetary discs circling newly formed stars. Where are these discs?
These discs are located between about 300 to 500 lightyears from Earth, so we are actually seeing the discs as they appeared 300 to 500 years ago. The regions in which these discs exist are some of the closest star-forming regions to our Solar System, which means we can get an excellent view of them.

▲ The molecules in protoplanetary discs can give vital clues about environments that could support life

How did you identify organic molecules from the Atacama Large Millimeter Array (ALMA) data?
Compared to previous instruments, ALMA has hugely increased our observational capability. It combines extremely high sensitivity with a high spatial resolution. This means we can detect faint emission on small scales, which was essential for our study. We searched for the unique 'fingerprints' of these molecules in the ALMA data, which were very faint, but thanks to the data's exceptional quality we were able to detect their emission.

Were these findings surprising?
These molecules have been detected in protoplanetary discs before, but the fact that we've been able to get such improved observations means the abundance of these molecules is much higher than previously thought. Additionally, they're located in the 'inner' disc regions, within about 50 astronomical units, which is approximately the same scale as our Solar System. This means we are finding significant amounts of prebiotic materials (which form the building blocks of life) on similar scales to a planetary system like our own.

How close are we to understanding what physical and chemical conditions result in planet formation around new stars?
The findings suggest that the chemical composition of discs that appear to be forming planets is similar to the composition of our own Solar System. However, we don't know if this is required to form planets. To investigate this we'd need to study the composition of a much larger and statistically significant sample of protoplanetary discs. This is something that ALMA will be able to do in the near future.

Dr John Ilee is an astrophysicist studying star and planet formation at the University of Leeds

Can these complex organic molecules be found only in protoplanetary discs?
Complex organic molecules are found in various environments throughout space, such as the giant clouds of gas and dust that will eventually go on to form stars. Studies have suggested that molecules such as these are the 'raw ingredients' for building molecules that are essential components in biological chemistry on Earth – including things like sugars and the bases of ribonucleic acid (RNA). However, many of the environments where we find these complex organic molecules are pretty far removed from where we think planets form. We wanted to understand more about where and how much of these molecules were present in the birthplaces of planets – protoplanetary discs.

Does the presence of such molecules suggest that a formed planet might eventually have environments that could create and sustain life?
While we can't say that for certain, the take-home message is that we find these 'prebiotic' molecules in large abundances, and at distances from their parent star that are similar in size to our Solar System. So that suggests the raw ingredients for life are plentiful in the disc of material that forms planets.

How do the protoplanetary discs tell you about the history of our Solar System's formation?
Three of the discs in our sample are around T Tauri stars, which are younger versions of stars that are similar to our Sun. These three objects represent a young stellar evolutionary stage that may go on to form a planetary system similar to our own.

What are the next steps for your research?
We want to know how the molecules got there. Had they been formed *in situ* by chemical reactions in the disc? Or have they been inherited from the earlier star-forming phase when the disc was assembled from a large cloud of gas and dust? Answering these questions would be one of our next steps.

THE SOUTHERN HEMISPHERE

With Glenn Dawes

Bright Venus and Jupiter hang out together all month, and we visit two galaxies in Dorado

When to use this chart

1 Feb at 00:00 AEDT (13:00 UT)
15 Feb at 23:00 AEDT (12:00 UT)
28 Feb at 22:00 AEDT (11:00 UT)

The chart accurately matches the sky on the dates and times shown for Sydney, Australia. The sky is different at other times as the stars crossing it set four minutes earlier each night.

FEBRUARY HIGHLIGHTS

This month, a spectacular naked-eye sight: a conjunction between Venus and Jupiter. Brilliant Venus is low in the western evening sky, with Jupiter to its upper right, their distance closing. They both outshine any star, with the crescent Moon chiming in on the 22nd just 1° from Venus – a pretty sight! The following evening they are 12° apart, forming a line with Jupiter in the centre. The month concludes with the planets separated by 2°, closing to only 0.5° on 2 March.

STARS AND CONSTELLATIONS

Alpha Canis Majoris (Sirius) forms a near perfect equilateral triangle with two other bright alpha stars, Procyon (in Canis Minoris) and Betelgeuse (in Orion). These make up the 'Winter Triangle'. The two 'Canis' constellations represent Orion the Hunter's dogs. Although Sirius looks the brightest, that is only because it is 8.5 lightyears away. Red supergiant Betelgeuse is 500 lightyears distant. If it matched Sirius's distance, it would glow as bright as a first quarter Moon!

THE PLANETS

The beacon of Venus can't be missed as it slowly crawls out of the western twilight sky. It is passed by Neptune mid-month (0.2° apart on 15th) and Jupiter at month's end, as both are swallowed by the twilight glow, heading for conjunction.

Mars is now well-placed in the early, northern evening sky. With the Red Planet departing around midnight, there is a dearth of planets until Mercury appears in the eastern pre-dawn sky. Its favourable morning apparition ends as February ends.

DEEP-SKY OBJECTS

This month, a trip to the far south to visit two very different galaxies in the constellation of Dorado. Beginning at Alpha Doradus, 2° west lies the face-on spiral NGC 1566 (RA 4h 20.0m, dec. –54° 56'). At 9th magnitude, it has a bright 2-arcminute core with a condensed nucleus. It is surrounded by a diffuse, mottled halo (5 arcminutes). A 20cm instrument reveals two distinctive spiral arms, where it gets its name, 'the Spanish Dancer'. There is a prominent 8th-magnitude star 6 arcminutes northwest.

Move a further 2.5° west to discover the edge-on spiral NGC 1515 (RA 4h 04.0m, dec. –54° 06'). In contrast to NGC 1566, this 11th-magnitude galaxy is highly elongated in shape (3.5 x 0.5 arcminutes) with an even illumination. Very large instruments (around 254cm) show some brightening in the centre.

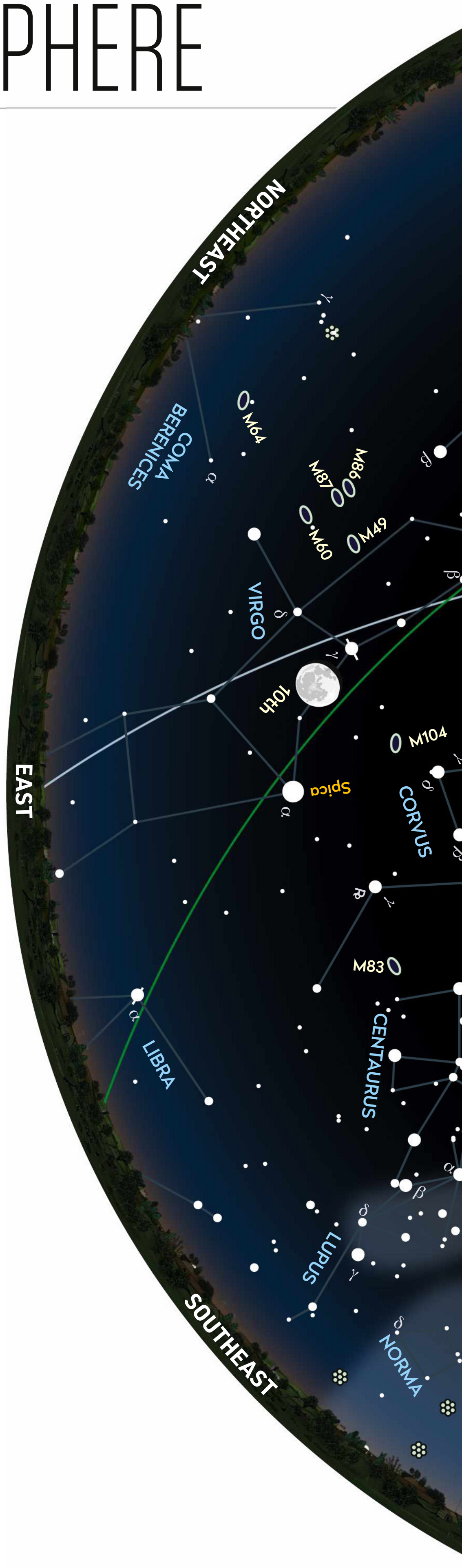
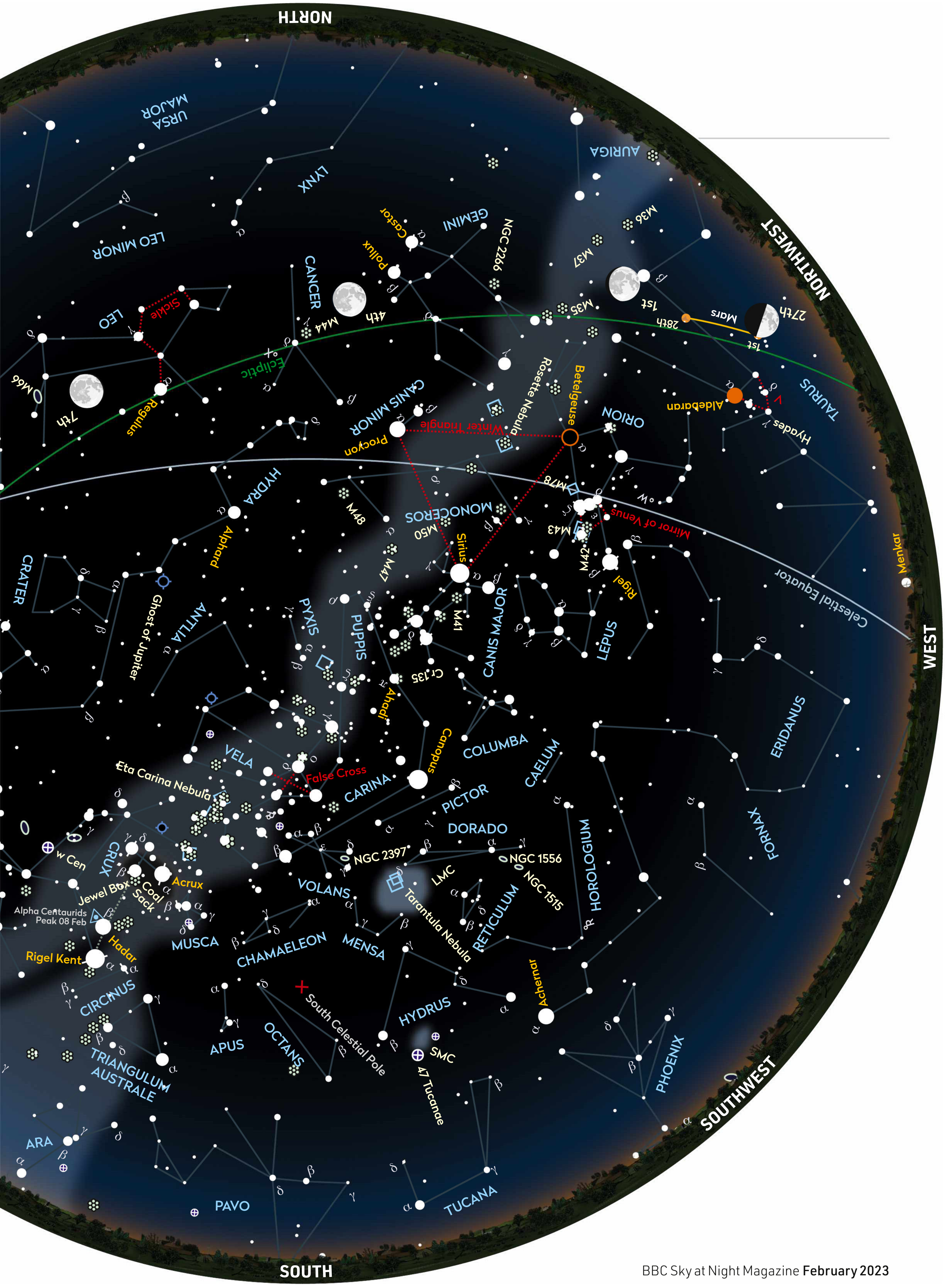


Chart key

GALAXY
OPEN CLUSTER
GLOBULAR CLUSTER
PLANETARY NEBULA
DIFFUSE NEBULOSITY
DOUBLE STAR
VARIABLE STAR
COMET TRACK
ASTEROID TRACK
METEOR RADIANT
QUASAR
PLANET
STAR BRIGHTNESS:
MAG. 0 & BRIGHTER
MAG. +1
MAG. +2
MAG. +3
MAG. +4 & FAINTER

CHART: PETE LAWRENCE



NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
URSA MAJOR
LYNX
AURIGA
LEO MINOR
GEMINI
Castor
Pollux
NGC 2266
M36
M37
M35
CANCER
M44
4th
1st
28th
Mars
27th
LEO
Sickle
M66
7th
Regulus
Ecliptic
CANIS MINOR
Procyon
Winter Triangle
Rosette Nebula
Betelgeuse
Aldebaran
TAURUS
Hyades
ORION
M78
HYDRA
Alphard
M48
MONOCEROS
M50
Sirius
M43
M42
Mirror of Venus
Rigel
Menkar
Celestial Equator
CRATER
Ghost of Jupiter
ANTLIA
PYXIS
PUPPIS
M47
M41
CANIS MAJOR
LEPUS
Cr 135
Adhara
Canopus
COLUMBA
CAELUM
ERIDANUS
VELA
Eta Carina Nebula
False Cross
CARINA
PICTOR
DORADO
NGC 2397
NGC 1556
NGC 1515
HOROLOGIUM
FORNAX
ω Cen
CRUX
Acrux
Jewel Box
Coal Sack
Alpha Centaurids Peak 08 Feb
Hadar
Rigel Kent
MUSCA
VOLANS
LMC
Tarantula Nebula
RETICULUM
CHAMAELEON
MENSA
Achernar
CIRCINUS
APUS
OCTANS
South Celestial Pole
HYDRUS
SMC
47 Tucanae
PHOENIX
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